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AN IMPROVED FEED-WATER HEATER AND PURIFIER.

By GEORGE S. STRONG.

[A paper read at the Stated Meeting of the Franklin Institute, June 21, 1882.]

In order to properly understand the requirements of an effective feed-water purifier it will be necessary to understand something of the character of the impurities of natural waters used for feeding boilers, and of the manner in which they become troublesome in causing incrustation or scale, as it is commonly called, in steam boilers. All natural waters are known to contain more or less mineral matter, partly held in solution and partly in mechanical suspension. These mineral impurities are derived by contact of the water with the earth's surface, and by percolation through its soil and rocks. The substances taken up in solution by this process consist chiefly of the carbonates and sulphates of lime and magnesia, and the chloride of sodium. The materials carried in mechanical suspension are clay, sand and vegetable matter. There are many other saline ingredients in various natural waters, but they exist in such minute quantities, and are generally so very soluble, that their presence may safely be ignored in treating of the utility of boiler waters.

Of the above named salts the carbonates of lime and magnesia are soluble only when the water contains free carbonic acid.

Our American rivers contain from 2 to 6 grains of saline matter to the gallon in solution, and a varying quantity—generally exceeding 10 grains to the gallon—in mechanical suspension. The waters of wells and springs hold a smaller quantity in suspension, but generally carry a larger percentage of dissolved salts in solution, varying from 10 to 650 grains to the gallon.

When waters, containing the carbonates of lime and magnesia in solution, are boiled, the carbonic acid is driven off, and the salts, deprived of their solvent, are rapidly precipitated in fine crystalline particles, which adhere tenaciously to whatever surface they fall upon. With respect to the sulphate of lime the case is different. It is at best only sparingly soluble in water, one part (by weight) of the salt requiring nearly 500 parts of water to dissolve it. As the water evaporates in the boiler, however, a point is soon reached where supersaturation occurs, as the water freshly fed into it constantly brings fresh accessions of the salt; and when this point is reached the sulphate of lime is precipitated in the same form and with the same tenaciously adherent quality as the carbonates. There is, however, a peculiar property possessed by this salt which facilitates its precipitation, namely, that its solubility in water diminishes as the temperature rises. This fact is of special interest, since, if properly taken advantage of, it is possible to effect its almost complete removal from the feed-water of boilers.

There is little difference in the solubility of the sulphate of lime until the temperature has risen somewhat above 212°Fahr., when it rapidly diminishes, and finally, at nearly 300°, all of this salt held in solution at lower temperatures, will be precipitated when the temperature had risen to that point. The following table* represents the

* *Vide* Burgh, Modern Marine Engineering, page 176 *et. seq.* M. Coustê, *Annales des Mines*, v, 69. *Recherches sur l'incrustation des Chaudieres à vapeur.* Mr. Hugh Lee Pattison, of Newcastle-on-Tyne, at the meeting of the Institute of Mechanical Engineers of Great Britain, in August, 1880, remarked on this subject, that "The solubility of sulphate of lime in water diminishes as the temperature rises. At ordinary temperatures pure water dissolves about 150 grains of sulphate of lime per gallon; but at a temperature of 255° Fahr., at which the pressure of steam is equal to about 2 atmospheres, only about 40 grains per gallon are held in solution. At a pressure of 3 atmospheres, and temperature of 302° Fahr., it is practically insoluble. The point of maximum solubility is about 95° Fahr. The presence of magnesium chloride, or of calcium chloride, in water, diminishes its power of dissolving sulphate of lime, while the presence of sodium chloride increases that power. As an instance of the latter fact, we find a boiler works much cleaner which is fed alternately with fresh water and with brackish water pumped from the Tyne when the tide is high than one which is fed with fresh water constantly."

solubility of sulphate of lime in sea water at different temperatures:

Temperature Fahr.	Percentage Sulph. Lime held in Solution.
217°	0·500
219°	0·477
221°	0·432
227°	0·395
232°	0·355
236°	0·310
240°	0·267
245°	0·226
250°	0·183
255°	0·140
261°	0·097
266°	0·060
271°	0·023
290°	0·000

These figures hold substantially for fresh as well as for sea water, for the sulphate of lime becomes wholly insoluble in sea water, or in soft water, at temperatures comprised between 280° and 300° Fahr.

It appears from this that it is simply necessary to heat water up to a temperature of 250° in order to effect the precipitation of four-fifths of the sulphate of lime it may have contained, or to the temperature of 290° in order to precipitate it entirely. The bearing of these facts on the purification of feed-waters will appear further on. The explanation offered to account for the gradually increasing insolubility of sulphate of lime on heating, is, that the hydrate, in which condition it exists in solution, is partially decomposed, anhydrous calcic sulphate being formed, the dehydration becoming more and more complete as the temperature rises. Sulphate of magnesia, chloride of sodium (common salt), and all the other more soluble salts contained in natural waters are likewise precipitated by the process of supersaturation, but owing to their extreme solubility their precipitation will never be effected in boilers; all mechanically suspended matter tends naturally to subside.

Where water containing such mineral and suspended matter is fed to a steam boiler there results a combined deposit, of which the carbonate of lime usually forms the greater part, and which remains more or less firmly adherent to the inner surfaces of the boiler, undisturbed by the force of the boiling currents. Gradually accumulating, it becomes

harder and thicker, and if permitted to accumulate, may at length attain such thickness as to prevent the proper heating of the water by any fire that may be maintained in the furnace. Dr. Joseph G. Rogers, who has made boiler waters and incrustations a subject of careful study, declares that the high heats necessary to heat water through thick scale will sometimes actually convert the scale into a species of glass, by combining the sand, mechanically separated, with the alkaline salts. The same authority has carefully estimated the non-conducting properties of such boiler incrustations. On this point he remarks that the evil effects of the scale are due to the fact that it is relatively a non-conductor of heat. As compared with iron its conducting power is as 1 to 37½, consequently more fuel is required to heat water in an incrusted boiler than in the same boiler if clean. Rogers estimates that a scale 1-16th of an inch thick will require the extra expenditure of 15 per cent. more fuel, and this ratio increases as the scale grows thicker. Thus, when it is one-quarter of an inch thick, 60 per cent. more fuel is needed; one-half inch, 112 per cent. more fuel, and so on.

Rogers very forcibly shows the evil consequences to the boiler from the excessive heating required to raise steam in a badly incrusted boiler, by the following illustration: To raise steam to a pressure of 90 pounds the water must be heated to about 320°Fahr. In a clean boiler of one-quarter inch iron this may be done by heating the external surface of the shell to about 325°Fahr. If now one-half an inch of scale intervenes between the boiler shell and the water, such is its quality of resisting the passage of heat that it will be necessary to heat the fire surface to about 700°, almost to a low red heat, to effect the same result. Now the higher the temperature at which iron is kept the more rapidly it oxidizes, and at any heat above 600° it very soon becomes granular and brittle, and is liable to bulge, crack or otherwise give way to the internal pressure. This condition predisposes the boiler to explosion and makes expensive repairs necessary. The presence of such scale, also, renders more difficult the raising, maintaining and lowering of steam.

The nature of incrustation and the evils resulting therefrom having been stated, it now remains to consider the methods that have been devised to overcome them. These methods naturally resolve themselves into two kinds, chemical and mechanical. The chemical method has two modifications; in one the design is to purify the water in large tanks or reservoirs, by the addition of certain substances which shall

precipitate all the scale-forming ingredients before the water is fed into the boiler; in the other the chemical agent is fed into the boiler from time to time and the object is to effect the precipitation of the saline matter in such a manner that it will not form solid masses of adherent scale. Where chemical methods of purification are resorted to the latter plan is generally followed as being the least troublesome. Of the many substances used for this purpose, however, some are measurably successful; the majority of them are unsatisfactory or objectionable.

The mechanical methods are also very various. Picking, scraping, cleaning, etc., are very generally resorted to, but the scale is so tenacious that this only partially succeeds, and as it necessitates stoppage of work, it is wasteful. In addition to this plan, a great variety of mechanical contrivances for heating and purifying the feed-water, by separating and intercepting the saline matter on its passage through the apparatus, have been devised. Many of these are of great utility and have come into very general use. In the Western States especially, where the water in most localities is heavily charged with lime, these mechanical purifiers have become quite indispensable wherever steam users are alive to the necessity of generating steam with economy.

Most of these appliances, however, only partly fulfill their intended purposes. They consist essentially of a chamber through which the feed-water is passed, and in which it is heated almost to the boiling point by exhaust steam from the engine. According to the temperature to which the water is heated in this chamber, and the length of time required for its passage through the chamber, the carbonates are more or less completely precipitated, as likewise the matter held in mechanical suspension. The precipitated matter subsides on shelves or elsewhere in the chamber, from which it is removed from time to time. The sulphate of lime, however, and the other soluble salts, and in some cases also a portion of the carbonates that were not precipitated during the brief time of passage through the heater, are passed on into the boiler.

Appreciating this insufficiency of existing feed-water purifiers to effectually remove these dangerous saline impurities, the writer in designing the feed water heater now to be described paid special attention to the separation of all matters, soluble and insoluble; and he has succeeded in passing the water to the boilers quite free from any substance which would cause scaling or cohérent deposit. His attention was more particularly called to the necessity of extreme care in this

respect, through the great annoyance suffered by steam users in the Central and Western States, where the water is heavily charged with lime. Very simple and even primitive boilers are here used; the most necessary consideration being handiness in cleaning, and not the highest evaporative efficiency. These boilers are therefore very wasteful, only evaporating, when covered with lime scale, from two to three pounds of water with one pound of the best coal, and requiring cleansing once a week at the very least. The writer's interest being aroused, he determined, if possible, to remedy these inconveniences, and accordingly he made a careful study of the subject, and examined all the heaters then in the market. He found them all, without exception, insufficient to free the feed-water from the most dangerous of impurities, namely, the sulphate and the carbonate of lime.

Taking the foregoing facts, well known to chemists and engineers, as the basis of his operations, the writer perceived that all substances likely to give trouble by deposition would be precipitated at a temperature of about 250°F.

His plan was, therefore, to make a feed-water heater in which the water could be raised to that temperature before entering the boiler. Now, by using the heat from the exhaust steam the water may be raised to between 208° and 212°F. It has yet to be raised to 250°F.; and for this purpose the writer saw at once the advantage that would be attained by using a coil of live steam from the boiler. This device does not cause any loss of steam, except the small loss due to radiation, since the water in any case would have to be heated up to the temperature of the steam on entering the boiler. By adopting this method the chemical precipitation, which would otherwise occur in the boiler, takes place in the heater; and it is only necessary now to provide a filter, which shall prevent anything passing that can possibly cause scale.

Having explained as is briefly as possibly the principles on which the system is founded, the writer will now describe the details of the heater itself.

In Figs. 1 and 2 are shown an elevation and a vertical section of the heater. The cast-iron base, *A*, is divided into two parts by the diaphragm *B*. The exhaust steam enters at *C*, passes up the larger tubes *D*, which are fastened into the upper shell of the casting, returns by the smaller tubes *E*, which are inside the others, and passes away by the passage *F*. The inner tube only serves for discharge. It will be

seen at once that this arrangement, while securing great heating surface in a small space, at the same time leaves freedom for expan sion and contraction, without producing strains. The free area for passage of steam is arranged to be one and a half times that of the

Fig. 1.
Elevation.

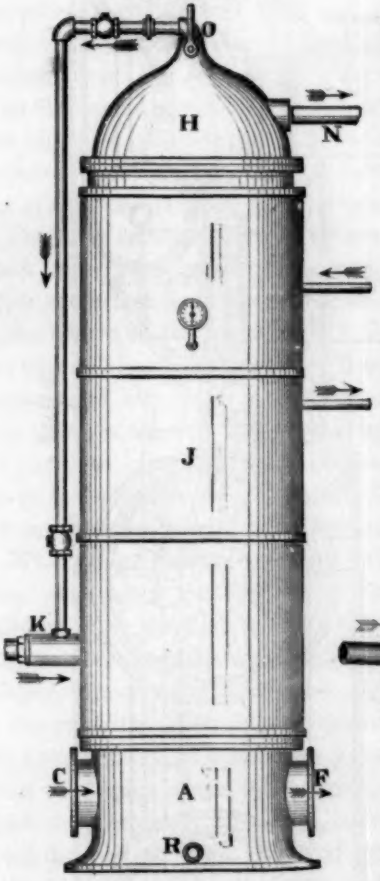
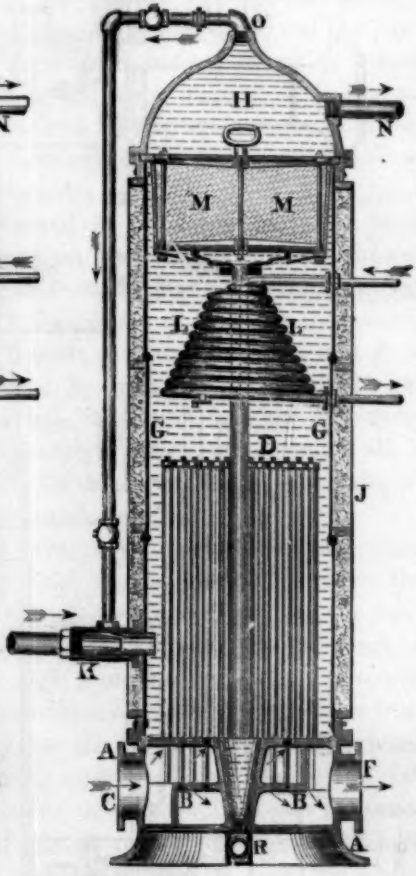


Fig. 2.
Vertical Section.



exhaust pipe, so that there is no possible danger of back pressure. The wrought iron shell *G*, connecting the stand *A* with the dome *H*, is made strong enough to withstand the full boiler pressure. An ordi- casing, *J*, of wood or other material prevents loss by radiation of heat.

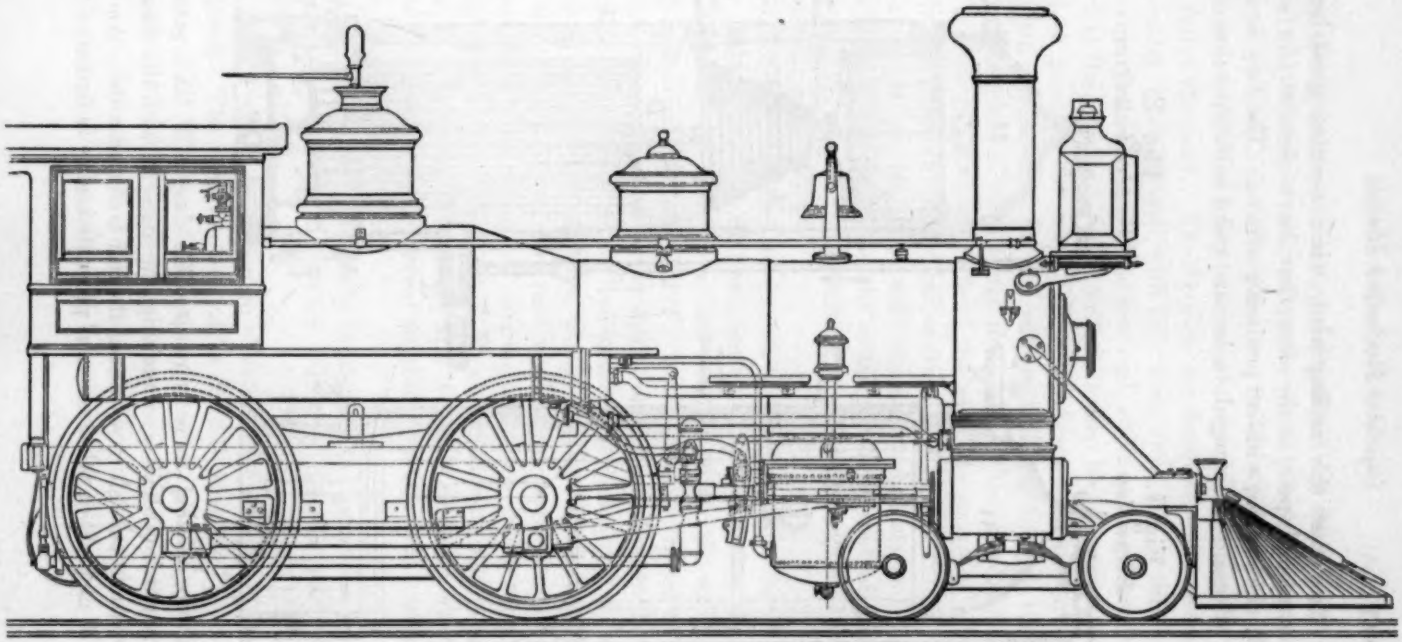


FIG. 3.

The cold water from the pump passes into the heater through the injector arrangement, *K*, and coming in contact with the tubes D is heated; it then rises to the coil *L*, which is supplied with steam from the boiler, and thus becomes further heated, attaining there a temperature of from 250° to 270°F., according to the pressure in the boiler. This high temperature causes the separation of the dissolved salts; and on the way to the boiler the water passes through the filter *M*, becoming thereby freed from all precipitated matter before passing away to the boiler at *N*. The purpose of the injector *K*, and the pipe passing from *O* to *K*, is to cause a continual passage of air or steam from the upper part of the dome to the lower part of the heater, so that any precipitate carried up in froth may be again returned to the under side of the filter, in order more effectually to separate it, before any chance occurs of its passing into the boiler.

The filter consists of wood charcoal in the lower half and bone black above, firmly held between two perforated plates, as shown. After the heater has been in use for from three to ten hours, according to the nature of the water used, it is necessary to blow out the heater, in order to clear the filter from deposit. To do this the cock at *R* is opened, and the water is discharged by the pressure from the boiler. The steam is allowed to pass through the heater for some little time, in order to clear the filter completely. After this operation all is ready to commence work again. By this means the filter remains fit for use for months without change of the charcoal.

Where a jet condenser is used either of two plans may be adopted. One plan takes the feed-water from the hot well and passes the exhaust from the feed pumps through the heater, using at the same time an increased amount of coil for the live steam. By this means a temperature of water is attained high enough to cause deposition, and at the same time to produce decomposition of the oil brought over from the cylinders. The other plan places the heater in the line of exhaust from the engine to the condenser, also using a larger amount of coil. Both these methods work well. The writer sometimes uses the steam from the coil to work the feed pump; or, if the heater stands high enough, it is only necessary to make a connection with the boiler, when the water formed by the condensation of the steam runs back to the boiler, and thus the coil is kept constantly at the necessary temperature.

In adapting the heater to locomotives we were met with the diffi-

culty of want of space to put a heater sufficiently large to handle the extremely large amount of water evaporated on a locomotive worked up to its full capacity, being from 1500 to 2500 gallons per hour, or from five hundred to one thousand HP. We designed various forms of heaters and tried them, but have finally decided on the one shown in the engraving, Fig. 3, which consists of a lap welded tube 13 inches internal diameter, 12 feet long, with a cast-iron head which is divided into two compartments or chambers by a diaphragm. Into this head are screwed sixty tubes, one inch outside diameter and 12 feet long, which are of seamless brass. These are the heating tubes within which are internal tubes for circulation only, which are screwed into the diaphragm and extend to within a very short distance of the end of the heating tube. The exhaust steam for heating is taken equally from both sides of the locomotive by tapping a two-inch nipple with a cup-shaped extension on it in such a way as to catch a portion of the exhaust without interfering with the free escape of the steam for the blast, and without any back pressure, as it relieves the back pressure as much as it condenses. The pipe from one side of the engine is connected with the chamber into which the heating tubes are screwed, and is in direct communication with them. The pipe from the other side is connected with the chamber into which the circulating tubes are screwed. The beat of the exhaust working, as it does, on the quarters causes a constant sawing or backward and forward circulation of steam without any discharge, and only the condensation is carried off.

The water is brought from the pump and discharged into the lower side of the heater well forward, and passes around the heating tubes to the end, when it is discharged into a pipe that carries it forward, either direct to the check or into the purifier, which is located between the frames under the boiler, and consists of a chamber in which are arranged a live steam coil and a filter above the coil. The water coming in contact with the coil, its temperature is increased from the temperature of the exhaust, 210°, to about 250° Fahr., which causes the separation of the lime salts as before described, and it then passes through the filter and direct to the boiler from above the filter, which is cleansed by blowing back through it as before described.

One of these heaters lately tested showed a saving in coal of 22 per cent. and an increase of evaporation of 1·09 pounds of water per pound of coal.

ECONOMICAL STEAM POWER.

By William Barnet Le Van.

[A paper read by title at the Stated Meeting of the Franklin Institute, Oct. 18, 1882.]

The most economical application of steam power can be realized only by a judicious arrangement of the plant: namely, the engines, boilers, and their accessories for transmission.

This may appear a somewhat broad assertion; but it is nevertheless one which is amply justified by facts open to the consideration of all those who choose to seek for them.

While it is true that occasionally a factory, mill, or a water-works may be found in which the whole arrangements have been planned by a competent engineer, yet such is the exception and not the rule, and such examples form but a very small percentage of the whole.

The fact is that but few users of steam power are aware of the numerous items which compose the cost of economical steam power, while a yet smaller number give sufficient consideration to the relations which these items bear to each other, or the manner in which the economy of any given boiler or engine is affected by the circumstances under which it is run.

A large number of persons—and they are those who should know better, too—take for granted that a boiler or engine which is good for one situation is good for all; a greater error than such an assumption can scarcely be imagined.

It is true that there are certain classes of engines and boilers which may be relied upon to give moderately good results in almost any situation—and the best results should *always* be desired in arrangement of a mill—there are a considerable number of details which must be taken into consideration in making a choice of boilers and engines.

Take the case of a mill in which it has been supposed that the motive power could be best exerted by a single engine. The question now is whether or not it would be best to divide the total power required amongst a number of engines.

First. A division of the motive power presents the following

advantages, namely, a saving of expense on lines of shafting of large diameter.

Second. Dispensing with the large driving belt or gearing, the first named of which, in one instance under the writer's observation, absorbed *sixty horse-power* out of about 480, or about *seven per cent.*

Third. The general convenience of subdividing the work to be done, so that in case of a stoppage of one portion of the work by reason of a loose coupling or the changing of a pulley, etc., that portion only would need to be stopped.

This last is of itself a most important point, and demands careful consideration.

For example, I was at a mill a short time ago when the governor belt broke. The result was a stoppage of the whole mill. Had the motive power of this mill been subdivided into a number of small engines only one department would have been stopped. During the stoppage in this case the windows of the mill were a sea of heads of men and women (the operatives), and considerable excitement was caused by the violent blowing off of steam from the safety-valves, due to the stoppage of the steam supply to the engine; and this excitement continued until the cause of the stoppage was understood. Had the power in this mill been subdivided the stoppage of one of a number of engines would scarcely have been noticed, and the blowing off of surplus steam would not have occurred.

In building a mill the first item to be considered is the interest on the first cost of the engine, boilers, etc. This item can be subdivided with advantage into the amounts of interest on the respective costs of,

First. The engine or engines;

Second. The boiler or boilers;

Third. The engine and boiler house.

In the same connection the *form* of engine to be used must be considered. In some few cases—as, for instance, where engines have to be placed in confined situations—the form is practically fixed by the space available, it being perhaps possible only to erect a vertical or a horizontal engine, as the case may be. These, however, are exceptional instances, and in most cases—at all events where large powers are required—the engineer may have a free choice in the matter. Under these circumstances the best form, in the vast majority of cases where machinery must be driven, is undoubtedly the horizontal engine, and the worst the beam engine. When properly constructed, the hori-

zontal engine is more durable than the beam engine, whilst, its first cost being less, it can be driven at a higher speed, and it involves a much smaller outlay for engine house and foundations than the latter. In many respects the horizontal engine is undoubtedly closely approached in advantages by the best forms of vertical engines; but on the whole we consider that where machinery is to be driven the balance of advantages is decidedly in favor of the former class, and particularly so in the case of large powers.

The next point to be decided is, whether a condensing or non-condensing engine should be employed. In settling this question not only the respective first costs of the two classes of engines must be taken into consideration, but also the cost of water and fuel. Excepting, perhaps, in cases of very small powers, and in those instances where the exhaust steam from a non-condensing engine can be turned to good account for heating or drying purposes, it may safely be asserted that in all instances where a sufficient supply of condensing water is available at a moderate cost, the extra economy of a well-constructed condensing engine will fully warrant the additional outlay involved in its purchase. In these days of high steam pressures, a well constructed non-condensing engine can, no doubt, be made to approximate closely to the economy of a condensing engine, but in such a case the extra cost of the stronger boiler required will go far to balance the additional cost of the condensing engine.

Having decided on the form, the next question is, what "class" of engine shall it be; and by the term class I mean the relative excellence of the engine as a power-producing machine. An automatic engine costs more then a plain slide-valve engine, but it will depend upon the cost of fuel at the location where the engine is to be placed, and the number of hours per day it is kept running, to decide which class of machine can be adopted with the greatest economy to the proprietor. The cost of lubricating materials, fuel, repairs, and percentage of cost to be put aside for depreciation, will be less in case of the high-class than in the low-class engine, while the former will also require less boiler power.

Against these advantages are to be set the greater first cost of the automatic engine, and the consequent annual charge due to capital sunk. These several items should all be fairly estimated when an engine is to be bought, and the kind chosen accordingly. Let us take the item of fuel, for instance, and let us suppose this fuel to cost four

dollars per ton at the place where the engine is run. Suppose the engine to be capable of developing one hundred horse-power, and that it consumes five pounds of coal per hour per horse-power and runs ten hours per day: this would necessitate the supply of two and one-half tons per day at a cost of ten dollars per day. To be really economical, therefore, any improvement which would effect a saving one pound of coal per hour per horse-power must not cost a greater sum per horse-power than that on which the cost of the difference of the coal saved (one pound of coal per hour per horse-power, which would be 1000 pounds per day) for say three hundred days, three hundred thousand (300,000) pounds, or one hundred and fifty tons (or six hundred dollars), would pay a fair interest.

Assuming that the mill owner estimates his capital as worth to him ten per cent. per annum, then the improvement which would effect the above mentioned saving must not cost more than six thousand dollars, and so on. If instead of being run only ten hours per day the engine is run night and day, then the outlay which it would be justifiable to make to effect a certain saving per hour would be doubled; while, on the other hand, if an engine is run less than the usual time per day a given saving per hour would justify a correspondingly less outlay.

It has been found that for grain and other elevators, which are not run constantly, gas engines, although costing more for the same power, are cheaper than steam engines for elevating purposes where only occasionally used.

For this reason it is impossible without considerable investigation to say what is really the most economical engine to adopt in any particular case; and as comparatively few users of steam power care to make this investigation a vast amount of wasteful expenditure results. Although, however, no absolute rule can be given, we may state that the number of instances in which an engine which is wasteful of fuel can be used profitably is exceedingly small. As a rule, in fact, it may generally be assumed that an engine employed for driving a manufactory of any kind cannot be of too high a class, the saving effected by the economical working of such engines in the vast majority of cases enormously outweighing the interest on their extra first cost. So few people appear to have a clear idea of the vast importance of economy of fuel in mills and factories that I perhaps cannot better conclude than by giving an example showing the saving to be effected in a large establishment by an economical engine.

I will take the case of a flouring mill in this city which employed two engines that required forty pounds of water to be converted into steam per hour per indicated horse-power. This, at the time, was considered a moderate amount and the engines were considered "good."

These engines indicated seventy horse-power each, and ran twenty-four hours per day on an average of three hundred days each year, requiring as per indicator diagrams forty million three hundred and twenty thousand pounds ($40\times70\times24\times300\times2=40{,}320{,}000$) of feed water to be evaporated per annum, which, in Philadelphia, costs three dollars per horse-power per annum, amounting to ($70\times2\times300=$ $420.00), four hundred and twenty dollars.

The coal consumed averaged five and one-half pounds per hour per horse-power, which, at four dollars per ton costs

$$\left(\frac{70\times2\times5{\cdot}5\times24\times300}{2000}\times4.00=\$11{,}088\right.$$

Eleven thousand and eighty-eight dollars.

Cost of coal for 300 days, ...	$11,088
Cost of water for 300 days, ...	420
Total cost of coal and water, ...	$11,508

These engines were replaced by one first-class automatic engine, which developed one hundred and forty-two horse-power per hour with a consumption of *three pounds* of coal per hour per horse-power, and the indicator diagrams showed a consumption of *thirty* pounds of water per hour per horse-power. Coal cost

$$\left(\frac{142\times3\times24\times300}{2000}\times4.00=\$6134\right)$$

Six thousand one hundred and thirty-four dollars. Water cost ($142\times3.00=$$426.00) four hundred and twenty-six dollars.

Cost of coal for 300 days, ...	$6,134
Cost of water for 300 days, ...	426
Total cost of coal and water, ...	$6,560

The water evaporated in the latter case to perform the same work was ($142\times30\times24\times300=30{,}672{,}000$), thirty million six hundred and seventy-two thousand pounds of feed water against (40,320,000), forty million three hundred and twenty thousand pounds in the

former, a saving of (9,648,000), nine million six hundred and forty-eight thousand pounds per annum; or,

$$\frac{40{,}320{,}000 - 30{,}672{,}000}{9{,}648{,}000} = 31{\cdot}4 \text{ per cent.}$$

Thirty-one and four-tenths per cent.

And a saving in coal consumption of

$$\frac{11{,}088 - 6{,}134}{4954} = 87{\cdot}5 \text{ per cent.}$$

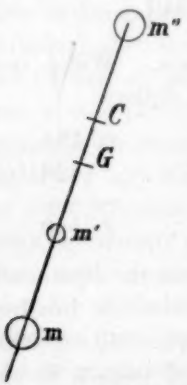
Eighty-seven and one-half per cent., or a saving in dollars and cents of four thousand nine hundred and fifty-four dollars ($4954).

In this city, Philadelphia, no allowance for the consumption of water is made in the case of first-class engines, such engines being charged the same rate per annum per horse-power as an inferior engine, while, as shown by the above example, a saving in water of *thirty-one and four-tenths per cent.* has been attained by the employment of a first-class engine. The builders of such engines will always give a guarantee of their consumption of water, so that the purchaser can be able in advance to estimate this as accurately as he can the amount of fuel he will use.

NOTE ON THE PENDULUM.

By John R. French, LL.D.
Professor of Mathematics in Syracuse University.

In certain vibrating clocks, the movement is retarded by the elevation of the "bob." Not having been able to find any discussion of the cause of this peculiarity of the pendulum, I present the following:



Let m'' be the mass of that part of the clock above the point of support C, supposed concentrated at the distance r'' of its centre of gravity from C. Let m' be the mass of that part of the clock below C, exclusive of the bob, similarly concentrated at the distance r' from C; and let m be the movable bob, whose distance from C is r. Let l be the length of a simple pendulum, whose vibrations are isochronous with those of the clock.

Then, from the familiar discussion of the compound pendulum ("Peck's Mechanics," p. 171),

$$(m'r' - m''r'' + mr)l = m'r'^2 + m''r''^2 + mr^2 \quad . \quad . \quad (1)$$

If an increment h be given to r, producing a change k in l, this equation becomes

$$(m'r' - m''r'' + m(r + h)(l + k) = m'r'^2 + m''r''^2 + m(r + h)^2 \quad . \quad (2)$$

Subtracting equation (1) from equation (2), we get

$$(m'r' - m''r'' + mr)k + m(hl + hk) = m(2hr + h^2) \quad . \quad (3)$$

If h and k are infinitesimally small, hk and h^2 may be dropped; then dividing equation (3) by hm, we have

$$\frac{m'r' - m''r'' + mr}{m} \cdot \frac{k}{h} + l = 2r \quad . \quad . \quad (4)$$

The first fraction in this equation must always be plus; since, in order to make vibrations possible, the centre of gravity G must be below C. Therefore equation (4) shows

1st. That if h and k are both plus, $r > \frac{1}{2}l$.
2d. That if $+ h$ produces $-k$, $r < \frac{1}{2}l$.
3d. That if, for $\pm h$, $k = o$, $r = \frac{1}{2}l$.

That is to say, if the bob is at a distance from C, the point of support, equal to half the length of a simple isochronous pendulum, a slight elevation or depression will produce no change in the rate of the clock. If it is below this point, its depression retards the vibrations, as in the ordinary clock; but if the bob is above this central point, the usual rule is reversed, viz.: the elevation of the bob retards, and its depression accelerates the motion.

This discussion holds good when $m'' = 0$, which is the case of the common pendulum.

Otherwise—

The moment of the accelerating force exerted by the mass m is ("Peck's Mechanics," *ibid.*):

$$m(l - r)rw,$$

in which w is the angular velocity and is constant for any given position of the pendulum. The varying part of the above expression, depending upon the position of the bob is, therefore,

$$u = lr - r^2,$$

whence

$$\frac{du}{dr} = r\frac{dl}{dr} + l - 2r \quad . \quad . \quad (5)$$

By differentiating equation (1) we deduce

$$\frac{dl}{dr} = \frac{m(2r - l)}{m'r' - m''r'' + mr}$$

which vanishes, for $r = \frac{1}{2}l$.

Omitting, therefore, the first term of the second member of equation (5)

$$\frac{du}{dr} = l - 2r$$

whence du, or the variation in the accelerating force, will be minus, plus, or zero, as r is greater, less than, or equal to $\frac{1}{2}l$, as before.

Syracuse, Sept. 15, 1882.

VISION BY THE LIGHT OF THE ELECTRIC SPARK.*

By W. Le Conte Stevens.

In former papers† the writer has discussed certain phenomena of vision under variable physiological conditions, and criticised the theory of the stereoscope as given in most of the text-books of Physics. While testing the effect of varying the strain upon the muscles of the eyes as a means of modifying the unconscious interpretation put upon the binocular retinal image, he was led to the discovery of a new mode of stereoscopy, in which a pair of absolutely similar pictures, such as a pair of like series of concentric circles on plane cards, are made to yield the binocular effect of convexity, flatness, or concavity, at will, by causing each card to rotate through any desired angle on a vertical axis, so that the two pictures are oppositely inclined to the horizontal visual lines. Since the retinal image is on a curved surface to which the visual line is approximately normal, while the plane of the card is oblique to this line, a circle on the card will be projected as a slightly distorted ellipse upon the retina. Assuming the two visual lines to be parallel and the distance between the centres

* Abstract of a paper read before the American Association for the Advancement of Science, at the Montreal meeting, August, 1882.

† *Am. Jour. Science*, Nov. and Dec., 1881; March, April and May, 1882; *London Philosophical Magazine*, Dec., 1881, and May, 1882; Journal of the Franklin Institute, May and Oct., 1882.

of the circles on oppositely inclined cards to be equal to the distance between the observer's optic centres, the distortions of the ellipses on the two retinas will be opposite in sense. We have thus slightly different retinal pictures in the two eyes at the same time, and the binocular effect is like that produced by a solid body in space, or by a pair of dissimilar photographs composing an ordinary stereograph.

This will be easily understood on reference to Fig. 1, where O and O' represent the observer's crystalline lenses, OC and $O'C'$ the horizontal visual lines, ED and $E'D'$ the horizontal diameters of a pair of circles on cards whose planes are perpendicular to that of the paper, these cards having been rotated about the vertical axes at C and C'

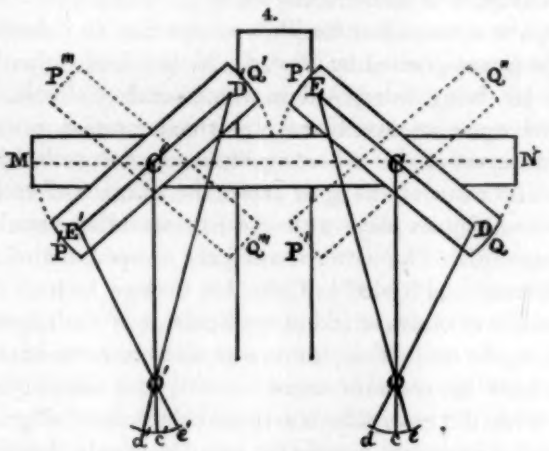


FIG. 1.

from an initial direction, MN, into the two directions, ED and $E'D'$, which are oppositely inclined to OC and $O'C'$. The retinal images, dce and $d'c'e'$, are necessarily unequally divided at c and c', dc being greater than $d'c'$. If the attention be withdrawn from C and C', while binocularly viewing the cards, to D and D', or E and E', the visual lines pass from parallelism into divergence. A slight additional strain is thus imposed upon the external rectus muscles of the eyeballs. The resulting tendency therefore is to make the observer imagine D and D', E and E' to be more remote than C and C'. The binocular image must hence appear convex.

Previous experiments on the visual effects resulting from muscular strain in the eyes suggested at once the explanation just given, on the

hypothesis that the eyes have freedom of motion in examining the pictures thus binocularly viewed. Many persons in making this experiment for the first time fail to attain any clear perception of depth in the binocular image until after the eyes have been directed successively to different parts of the field of view. The conditions are a little unusual and momentary confusion is the result. The writer deemed it worth ascertaining whether the perception of such depth is attainable by momentary illumination of the cards, during which play of the eyes is impossible and hence cannot be considered in explanation of the phenomenon; in other words, whether the explanation already advanced was itself sufficient, or only supplementary to other considerations, though true so far as it goes.

The apparatus employed for illumination was an induction coil, the use of which was granted by Prof. O. N. Rood, of Columbia College, a Leyden jar being interposed in the secondary circuit. The cards were placed upon an attachment, by which rotation could be given them on the arms of the reflecting stereoscope described in a former paper.* The value of the optic angle, the distance of each card, and the angle made by its plane with the corresponding visual line could thus be recorded. The writer secured the co-operation of Mr. W. W. Share, assistant in Physics in Columbia College, each of the two acting alternately as observer and as manipulator of the apparatus.

Arranging the arms of the stereoscope so as to necessitate parallelism of visual lines the observer seated himself, with closed eyes, in proper position, while the manipulator arranged the pair of diagrams so as to produce either concavity, convexity, or planeness in the binocular picture. The room was then darkened, and, on the passing of a spark, the observer was requested to interpret the form of the binocular image, of which he was necessarily previously ignorant. It was found usually possible, on first trial, to secure a correct interpretation, whether the diagrams had been made in such manner as to produce the appearance of relief in the ordinary stereoscope, or whether concentric circles oppositely inclined to the two visual lines were employed. When the arms of the stereoscope were so arranged as to produce slight divergence or strong convergance of visual lines, the proper relation between these by trial required the transmission of more than one spark before the requisite adjustment was secured, but binocular relief became at

* Journal of the Franklin Institute, October, 1882.

once perceptible, with the same variation in apparent size and distance of the image that had formerly been produced under continuous light. The abnormal conditions, however, made it more difficult to form reliable judgments. A series of such experiments, therefore, was made by Mr. Share and the writer, with results quite similar to those already published.

Knowing the distance of the cards, the diameter of each circle, the angle made by its plane with the visual line, and the distance from nodal point to retina in the observer's eye, and assuming parallel vision, it becomes possible to calculate the degree of distortion of each ellipse as projected on the retina, and thus to calculate the maximum "retinal displacement" that under the given conditions can co-exist with clear binocular vision. If each eye be directed to the centre of the circle in front of it the greatest displacement obviously corresponds to the marginal portions of the binocular image. The unity of the image remained thus apparent when the retinal displacement was more than 3 mm., an interval so far exceeding the estimated *minimum visible* as to preclude retinal fusion. Indeed, by giving the attention, through indirect vision, to these marginal parts without changing the direction of the visual lines, double images were at once detectible, while the perception of relief became less clear. This was observed by both Mr. Share and the writer. On the other hand, experiments were made to ascertain the minimum rotation of the cards that was necessary to change the binocular image from a plane to a perceptibly curved surface. An angle of one degree was found sufficient; the resulting retinal displacement being so small that no double image could be perceived under such circumstances with even the acutest vision thus far tested.

These experiments therefore tend to confirm the conclusion reached by Helmholtz, in opposition to many other physiologists, that neither play of the eyes nor the perception of double images is necessary to the distinctness of binocular vision, however important these elements may sometimes be in confirming our visual judgments, conscious or unconscious. Indeed, the perception of double images requires a special act of attention; and if the production of these is a necessary incident in all binocular vision at short distances—and this is unquestionably true,—the conscious perception of them interferes with the clearness of such vision instead of being a necessity. Each eye transmits its own separate sensation to the brain, and the resultant idea is referred to the external thing, not consciously to the sensation. Many of our judg-

ments, not only in vision but in the performance of other bodily functions, are instantaneous and unconscious; but probably we shall never be able to put an exact dividing line between those due to the experience of the individual and those that spring from tendencies transmitted by the race. If passive seeing be a result of mere inheritance, then active looking is superadded as a result of training. By oft-repeated efforts, which form a succession of experiences, we learn to see, just as we learn to walk or talk in infancy. We may attain the mechanical analysis of walking and even talking, knowing the structure of the organs employed and the relative positions of the various parts. The analysis of binocular vision, in a similar way, has been tried, but unsuccessfully. Thus far we can only say that, for each individual, personal experience has established a relation between certain complex sensations and external realities, and that not only binocular but even monocular vision is in every case the product of a judgment quickly reached, and by no means always, or even ordinarily, capable of separate analysis, because of the unconsciousness with which it is formed.

NOTES ON WATER ANALYSIS.

By Reuben Haines.

No. 1.

[Read before the Chemical Section, Franklin Institute, Sept. 5, 1882.]

Within the past few years renewed efforts have been made to place the much troubled subject of water analysis in a more satisfactory condition. Among others may be mentioned the recent investigations under the direction of the National Board of Health of this country. Difficulties of an extraordinary character are experienced, inasmuch as the chemist is called upon not only to estimate quantitatively substances of the properties and constitution of which he knows little or nothing, and of the very existence of which he may be doubtful, but also he is expected to state his opinion as to their physiological effects when taken within the human body. In the latter demand may be said to lie in the majority of cases the exclusive interest of his client. People usually do not care much about the figures in the analysis; they simply want to know authoritatively, with certainty, whether the

water is wholesome, and if not what is the cause and how it can be remedied. To answer these questions an exact quantitative analysis is considered necessary.

These difficulties are made a hundredfold greater by the fact, apparently well established, that some of these substances, whatever they may be, whether living or dead, can produce manifest effects when present in exceedingly minute quantity. Add to this the fact that owing to different methods of analysis being used and different views being held as to the significance of the several results of analysis, the most diverse opinions have occasionally been expressed in regard to the wholesomeness of the water supply of a city or town by chemists of established reputation. Unfortunately some of these opinions have been expressed with a positiveness unwarranted by the state of our knowledge.

Surely any well-directed and well-intentioned effort to relieve this important subject of some of its difficulties is commendable. Chemists are therefore to be congratulated, as being one of the steps toward this end, on the greater disposition to recognize the respective merits and demerits of rival methods of research. The feeling is becoming more evident that no single method of analysis now used can with any probability tell the whole story, and also that chemical must of necessity be coupled with microscopical and biological studies in many sanitary water analyses. In other words, every ray of light gathered from all the various sources that can be thought likely to illuminate this confessedly obscure subject should be utilized in every important investigation. It is a matter of importance, therefore, that any method of analysis which is widely adopted should be worked in such a manner that it will give uniform and strictly comparable results in the hands of different but equally conscientious chemists. Any effort to elucidate causes of variation should therefore be welcomed, however trivial and unimportant they might at first appear. This must, therefore, be my apology in offering the present paper.

Wanklyn's ammonia method is very extensively used, but the descriptions of it and of the judgment to be placed on a given water, which are to be found in the five successive editions of his manual of water analysis, are, on a number of points, in the opinion of some, by no means entirely satisfactory. Neither do the various scattered papers on this subject by other chemists agree very well among themselves or with Mr. Wanklyn's instructions. It thus appears evident

that Mr. Wanklyn unfortunately has not described his method with sufficient detail on some important points so as to enable other chemists less experienced in water analyses to obtain strictly reliable results, or as nearly so as is attainable by his method. In its conception the method appears very simple and easy to follow, but the precautions found necessary by experience are numerous, and on these points Mr. Wanklyn allows his readers to rest too much on their own unaided judgment, or states his opinion in a brief, *ex-cathedra* manner not at all satisfactory to the thoughtful student when he finds an opposite opinion expressed by an equally accomplished chemist. This is particularly to be regretted where, unlike the analysis of a mineral ore or technical product, the judgment of the chemist based upon the analysis is of far greater importance than the analytical results themselves. In such cases the fullest explanations of the basis of the opinions expressed should be given by the author of the manual, especially in the later editions when the method is being extensively adopted. It is, therefore, a matter of regret that the last edition contains so little change from those preceding by way of suggestion, hint, or explanation which ought reasonably to follow from more extensive use. It seems probable that to this deficiency may be traced many erroneous, and in some cases worthless, analyses that have been made, upon the results of which the question of sanitary improvements on a large scale were to be decided.

In view of all the points just considered, I offer the following description of the manner of working the method, not imagining, however, that it is the best that can be devised, but simply as one which I have found to give satisfactory results. I hope it may prove suggestive of improvements and may lead to a uniformity of practice. As compared with this the mere statement of results in a uniform manner is of comparatively insignificant importance, although also desirable.

For the details of the method, which are not included in this paper, I refer to Wanklyn's Manual.

On the Albuminoid Ammonia Method.

In working the ammonia process of Wanklyn it is advantageous to connect the retort and condenser by means of a short piece of wide rubber tubing. The retort, selected of commercial pint size, but capable of holding more than one litre, should have a rather narrow neck,

which can easily be thrust within the tube of the Liebig condenser to the distance of five or six inches without the glass surfaces being in actual contact. If the retort neck is rather too slender slip a second short piece of rubber tubing up the neck and thrust the latter into the condenser until the two pieces of rubber overlap each other. The rubber should always be tied down with cord, both on the condenser and on the retort, because it expands and loosens its grip on the glass during the distillation. Before connecting them, every part, including the rubber, is thoroughly washed with clean tap-water and they are then immediately put together.* The retort, if it is new, or if it has been used just previously for very bad waters, should in the first place be rinsed out with about 10 cc. of concentrated sulphuric or hydrochloric acid. When the apparatus is once set up many analyses may often be made on successive days, or at longer intervals, without its becoming necessary to disconnect the parts. In this case, before pouring in the sample to be analyzed, flush the whole apparatus with tap-water conveyed by rubber tubing to the tubulure of the retort, into which a short glass tube, bent at a sharp angle, is inserted so that the jet of water is thrown directly into the neck of the retort. Into the beak, or smaller end, of the condenser a clean cork is inserted and the whole tube and retort neck filled with water. When the water begins to overflow into the body of the retort the cork plug is removed and the whole mass of water allowed to rush out. This flushing is repeated two or three times, and the outside of the beak of the condenser is also washed by pouring clean water over it. The water which has collected in the retort is removed by a glass syphon, which has been just previously well washed. At the conclusion of an analysis the permanganate liquid is removed by the syphon, introducing clean water and syphoning it out until no longer colored.†

* It may be proper to state that at the time of presenting this paper I had not read the articles on this subject which appeared during the early part of this year in the *Analyst*, in which a similar arrangement of the retort is recommended.

† It should be stated that the working details to be described may perhaps prove to be better adapted to the analysis of soft waters, or those waters the hardness of which is due to sulphates rather than carbonates. A number of the hard waters from the neighborhood of Philadelphia, which I have analyzed, are of this character. It is not likely, however, that calcium and magnesium carbonates would form any strongly adherent deposit on the bottom of the retort in a boiling liquid of comparatively high specific gravity, such as the permanganate liquid becomes. I have usually found that the deposited carbonates could be almost completely syphoned out by doing it while the liquid is still hot.

In the case of very bad waters, however, a deposit of manganese oxide often forms on the bottom of the retort, which, if allowed to accumulate, may cause violent bumping, thereby endangering the retort and contaminating the distillates with permanganate. In such cases it is necessary to disconnect the apparatus and clean out the retort with a little hydrochloric acid, taking care to wash very thoroughly afterward. The slight film of manganese oxide frequently forming high up on the sides of the retort may, however, be neglected as having no injurious influence. The prevention of this sudden bumping is sometimes a very troublesome matter. I find that it ocsasionally occurs with soft spring waters of first-class purity, and it cannot then be attributed to an accumulated deposit on the retort. A very pure spring water, which I have examined a number of times, has invariably bumped, often two or three times during a single distillation, with permanganate and so badly as to foam up and flood the condenser without any warning or noise, even when the retort neck was inclined upward. It appeared rather to be owing to a sudden liberation of steam throughout the whole mass of liquid at once, but ignited fragments of pumice introduced into the retort did not check it. On the other hand, when an organic liquid, such as diluted milk, was introduced into the retort with this same spring water and permanganate, as in Wanklyn's method for estimating the albuminates in milk, the distillation, which before was very turbulent, now immediately became regular and tranquil, with no bumping, and small bubbles breaking on the surface instead of the large ones of the previous distillation to purify the water. On syphoning out the liquid after the operation was finished a considerable deposit of oxide, formed by the reduction of the permanganate, was found adhering to the bottom of the retort.

Several methods of avoiding this difficulty have been suggested in Wanklyn's Manual and in various papers in chemical journals. Some advise introducing into the retort recently ignited pieces of pumice or tobacco pipe, or else a judicious shaking or tapping of the retort during the distillation so as to produce a wavy motion in the liquid, or inclining the retort upward so that the liquid may not enter the condenser. I have tried all of these methods, but find the following plan decidedly preferable to any of them. I watch the retort very closely during the whole distillation when the trouble is likely to occur, and at the instant that the liquid is observed to foam up snatch

away the Bunsen burner from below the retort, replacing it when the foam subsides. This may have to be repeated several times. In very troublesome cases it is well to keep the hand upon the burner ready to remove it instantly. Toward the latter end of the distillation spirting of the concentrating liquid is apt to occur. This may be checked by regulating the flame by a screw spring compressor on the rubber gas tubing and distilling more slowly. If a fourth or fifth portion of 50 cc. has to be distilled over, the flame should be lowered to prevent the fracture of the retort, or else from 100 to 200 cc. of perfectly pure distilled water should be added to the retort. The distillation should be continued until 50 cc. of the distillate develops no color with Nessler test on standing several minutes, or a least contains not more than ·005 mgm. NH_3. This can be ascertained by nesslerizing the third or fourth 50 cc. distillate while the following one is distilling. It is sometimes necessary to estimate the ammonia in the fifth or even in the sixth 50 cc. portion, but usually the fourth portion contains less than ·005 mgm. NH_3. Of course, the free ammonia must be known to be completely expelled before commencing the distillation with permanganate; hence, in highly ammoniacal waters it is best, after distilling off 200 cc., to distill and nesslerize a succeeding 50 cc. before adding the permanganate to the retort.

In many cases the precautions above given against bumping will be found quite unnecessary, and other parts of the analysis, viz., the nesslerizing the free ammonia and the estimation of the chlorine, may be attended to during the progress of the distillation. If the albuminoid ammonia distillates are nesslerized in the reverse order, the third before the second and the second before the first, a tolerably accurate guess can be made at once as to the amounts of ammonia in each. In very many cases in my experience the first portion contains about twice the second and the second twice the third. We thus know at once whether it will be best to dilute the first distillate before adding the Nessler solution. Some waters, as for example those which are turbid with organic matter, or peaty waters, will not be likely to follow this rule, and some analysts have claimed that the manner in which the distillation progresses is a means of distinguishing vegetable from animal organic manner, or at least affords information which is an aid in forming a judgment of the quality of the water. It would seem best, therefore, to measure accurately each separate distillate and keep

on permanent record the amount of ammonia which it contains.* If the water contains so much free ammonia as to give a decided color with the Nessler test in 50 cc. of the sample without distillation the free ammonia can be more accurately estimated by distilling off 200 cc. in one portion, diluting with ammonia—free distilled water, taking out an aliquot part, and diluting again, if necessary, to 50 cc.; nesslerize this and multiply by the proper factor. Some of these ammoniacal waters appear to yield four-fifths, or even five-sixths, of the total amount of the free ammonia in the first 50 cc. distilling over, instead of three-fourths, which is usually the case as stated by Wanklyn. This variation is of no practical importance, however, since such a water would certainly be condemned by either method of calculation if it comes from a shallow well or spring.

In the distillation it is necessary to have a current of water through the condenser sufficiently rapid to avoid perceptible heating of the latter, except at the outlet. I prefer to use a 4-jet Bunsen burner, and operate on a half litre of the sample. I have obtained identical results when using quantities of half litre and full litre of the same water on the same day, or as nearly identical as is possible in these colorimetric estimations. My own limit of accuracy in colorimetric observation in matching the colors I have found to be ·002 milligram of ammonia in amounts of more than ·010 mgm. in 50 cc. of water. Hence, a plus or minus error of this amount is liable to occur in every nesslerizing. I believe, however, that these errors, to some extent at least, neutralize each other, since several duplicate analyses can be made agreeing much more closely than would be the case if the errors were all in one direction. Moreover, the corresponding distillates in different duplicate analyses are often found to contain identical amounts of ammonia, which, of course, fortifies their accuracy, provided that the distillates are of equal volume. Although working on amounts of a full litre avoids the doubling of this error, there are counterbalancing disadvantages attending it. It is, of course, very necessary for the chemist to ascertain if he is afflicted in any degree with color blindness. If he is color blind only to a very insignificant extent, it may possibly be expressed quantitatively, and allowed for as a sort of "personal equation." But if this defect is very marked it is hardly necessary to say

* The author of the paper in the *Analyst* cited above recommends mixing all the albuminoid distillates, measuring out an aliquot part, and making but one nesslerizing. It might be well to compare the numerical accuracy of the two methods.

he ought to relinquish the practice of this method of water analysis, and perhaps all other methods necessitating colorimetric observation. This precaution is of some importance from the fact ascertained by statistics, that about one man in twenty is more or less color-blind. Among women the percentage having this defect is much less. I find it is very difficult to estimate the color when less than ·005 mgm. of ammonia is found in 50 cc. of the distilled water; hence, amounts of less than this figure are neglected in adding up for the total amount. I do not think this error of omission can be avoided by distilling the albuminoid ammonia in one portion, returning this to the retort and redistilling in separate portions of 50 cc. each, as was suggested by Mr. Sidney Rich, for waters containing small amounts of albuminoid ammonia. Due allowance must, therefore, be made for these possible errors in the estimations of colors, when analyses of different samples of water are compared with each other, and a slight difference in results may indicate no real difference in the quality of the waters under examination.

It is highly important to have the alkaline permanganate solution perfectly free from ammonia. This degree of purity I have been unable to obtain by following any of the directions for its preparation heretofore published. Dr. Tidy, in a paper on the methods of water analysis, read before the (London) Chemical Society, Dec. 5, 1878 (*J. Chem. Soc.*, vol. 35, page 62), states that he believes "it to be practically impossible to prepare alkaline solutions of potassic permanganate absolutely free from ammonia. I have, myself," he says, "followed with the greatest precision the details given by Mr. Wanklyn for its preparation, and, moreover, have tried a large number of other means that have suggested themselves, such as fusing the potash before dissolving, and such like, without avail. Nor have I found any permanganate solution made by others which was entirely free from ammonia. Hence it has always been necessary to estimate the quantity of ammonia in the permanganate solution, and to deduct this from the total amount obtained in the actual experiment."

In the discussion of this lengthy and important paper, which was postponed to take place at a special meeting on Feb. 6, 1879, Mr. Wanklyn, toward the close, stated that "he had never had any difficulty in obtaining his alkaline permanganate free from ammonia, and he could not tell what results might be arrived at by using impure solutions of permanganate, and allowing for the impurity" (*Chemical*

News, Feb. 14, 1879). This remark was elicited by a question in regard to some extraordinary discrepancies in the analysis of certain London waters, by two chemists, both of whom used the ammonia method. Mr. Wanklyn, however, appears not to have explained how he obtained a pure solution of permanganate.

I have found it possible to prepare the permanganate solution so pure that when a litre of it is distilled *by itself in an undiluted condition* it will yield in the first 50 cc. distillate, not more than ·005 mgm. of ammonia. To obtain it in this condition, I dissolve the required amounts of caustic potash (white sticks), and of permanganate in separate portions of ordinary distilled water; then mix, and dilute further to about 1500 cc., and boil down rapidly in a capacious flask over a Bunsen burner to about 500 cc.; then dilute again to about 1200 cc. with ordinary distilled water, and boil again, as before, to about 900 cc.; when cool make up the litre mark with water which has been redistilled with alkaline permanganate till free from all traces of ammonia and organic matter. I have secured the same result by diluting in the first place to more than two litres with ordinary distilled water, and rapidly boiling down to about 900 cc., and then at once making up when cool to the litre mark in the manner described. If I used ordinary Schuylkill river water for making the solution I found it was practically impossible to get it free from ammonia, nearly equal amounts continually coming over in the protracted distillation. In laboratories where the water supply is limited the flask need not be connected with the Liebig condenser until the boiling is nearly completed. This attachment is conveniently made by means of a large glass tube, bent at a right angle, and fitted to the flask and to the condenser by two pieces of wide rubber tubing, in such manner that it is only very slightly exposed to the action of the steam. It is scarcely necessary to add that it should be very thoroughly washed just before being attached. If, on testing the distillate, more than ·005 mgm. of ammonia is found the solution in the flask must be boiled longer or distilled water added and boiled down again as before. Care should be taken not to concentrate the solution too far, as it may thus suffer decomposition, and pass over into the green manganate with evolution of oxygen. This accident occurred twice with the present writer. This fact was also noticed by Mr. Wanklyn, as stated in the *Philosophical Magazine* for Feb., 1879. He says that "at temperatures very little above 100°C. a mixture of pure K_2Mn

O_4 and KHO evolves oxygen gas." In the concentrated liquid the boiling point rises, of course, in proportion to the degree of concentration. "The gas is evolved very freely at temperatures even below 140°C., and the numerical results accord very well with the equation $2(KMnO_4) + 2(KHO) = 2(K_2MnO_4) + H_2O + O$. Hence the permanganate loses one-fifth of its active oxygen and becomes manganate of potash." I have also found that if the requisite quantities of permanganate and of caustic potash are dissolved in separate portions of water of somewhat more than one-half litre each, and a part of the permanganate is then poured into the potash solution while quite warm, the permanganate is, in a few minutes, completely reduced to the green manganate. It seems, therefore, that the mixing should always be done in the reverse manner and when the solutions are cold; that is to say, the potash solution sufficiently diluted should be gradually added to a dilute solution of permanganate.

In boiling the mixed solutions the appearance of numerous small bubbles over the surface of the concentrated liquid will be found to indicate that the solution is losing oxygen.

With the solution made in manner described I have found some shallow well waters so pure as to yield only ·026 mgm. per litre (or parts per million) total albuminoid ammonia, without correction, and including in the calculation the ·005 yielded by the last distillate which gave the slightest color by the Nessler solution. Obviously no correction was admissible in such cases.

I believe, with Mr. Wanklyn, that it is unsafe to use an impure solution of permanganate, and make a correction for that impurity. Some time ago when using a solution of much less purity than the one described, I found several instances where, in distilling off the albuminoid ammonia from spring waters of the very purest character, the total amount of this ammonia obtained was less than the amount of correction which was to have been made for the ammonia in the 50 cc. of permanganate used in the analysis. In other words, part of the ammonia had disappeared or was not developed in the diluted permanganate in the retort.

The Nessler solution I have found to be more satisfactorily prepared according to the directions of Dr. Frankland than according to those of Mr. Wanklyn. Particular care should be taken to render it sufficiently sensitive by a little additional mercuric chloride solution. In nesslerizing 50 cc. containing ·040 mgm. ammonia the full color

ought to be developed almost immediately, and no change in intensity ought to be perceptible after half a minute has elapsed. In solutions containing less ammonia the color is developed more slowly, but with even so little as ·005 mgm. the color ought to be fully developed in less than two minutes. The whole estimation should be concluded as soon as possible for several reasons, one of which is that occasionally a turbidity will occur in the nesslerized distillates in about ten or fifteen minutes, or a bright red precipitate will sometimes be found at the bottom of the glass when exposed to bright light, both of which occurrences are altogether fatal to any accuracy. The rapidity of development of the full color produced by the Nessler solution is believed to be wholly dependent upon the degree of sensitiveness imparted by additional mercuric chloride to the Nessler solution. My experience in the rate of this development differs from the author of the articles in the *Analyst* cited near the beginning of this paper, and leads me to suppose that his solution was not made as sensitive as may be possible.

The storage bottles of the Nessler solution should be kept as full as possible, the stoppers of which may be coated with paraffin, and a smaller bottle should be kept for immediate use. For this purpose I prefer to use a 2 oz. wide-mouthed, glass-stoppered bottle, the stopper of which has never become tight, although it is not paraffined, which is, I think, an advantage in a bottle which is so constantly opened. This stopper is always replaced immediately after taking out the 2 cc. by the pipette for each nesslerizing, as the solution should be exposed as little as possible to the atmosphere of the laboratory. By using the volume pipette with proper care the flocculent sediment which gradually forms at the bottom of the bottle produces little or no inconvenience to the operator, and only a very little of the solution need be thrown away at the last. The pipette for the Nessler solution serves also as a stirrer, and should always be washed immediately before and after each nesslerizing. This can be conveniently done by plunging the stirrer each time into a larger and firmly standing cylinder containg water which is fairly free from ammonia. If river water does not give the faintest color with the Nessler test when not distilled it is sufficiently pure for this purpose. This water must of course be changed after a few testings. To make sure that everything is going on right it is well to have a blank nesslerizing cylinder handy containing water free from ammonia. By experience one can guess

quite closely at the amount of ammonia present immediately after dropping in the Nessler solution, and it is not necessary to wait for the full development of the color before making up the comparison cylinder. Hence, all the distillates and comparison cylinders can be nesslerized in rapid succession. Since it is only occasionally that the experienced analyst finds it necessary to make up anew a second comparison cylinder of a different strength, the whole series of Nessler tests can often be completed within a very few minutes if all the apparatus required is ready for use at his elbow.

I have dwelt particularly on this point because some chemists appear to have been dissatisfied with the slowness and tediousness they have experienced in this operation, and on this account have been led to devise various methods and appliances for shortening it. Thus, some have used comparison tubes containing standard caramel solutions, either simple or those brought to the proper tint by the addition of colors like aniline red, etc. Otto Hehner devised a cylinder, graduated on the side and with a glass tap at the base, and estimated the amount of ammonia by the height of the column of liquid when the tints were equalized. Prof. A. R. Leeds has devised an expensive apparatus carrying two glass reflectors, between which the nesslerized cylinders are placed, and the colors estimated in comparison with light passing through a prism containing a solution of caramel and aniline red. Although I have never used Leeds' apparatus, I think I can endorse the opinion I have seen somewhere expressed by an English chemist that all of these supposed aids will prove only to be hindrances to the experienced worker, and their proper management consumes more time than the original unaided method. It has some years ago also been shown that it is frequently impossible to secure the proper tint by caramel solution, and a mixture of caramel with such colors as aniline will be apt to change in a short time on exposure to light. I have tried the simple caramel solution, and, as it has been the experience of other chemists, I have been compelled to abandon it. I have no doubt, however, that for such colorimetric estimations as Eggert's method for carbon in steel Leeds' apparatus will prove a useful aid.

In regard to the time consumed in nesslerizing it will be understood that the purer the water under examination the more rapid are the testings; for with impure waters the distillates must be measured, diluted and an aliquot part taken for the nesslerizing which latter may

have to be repeated several times before a convenient color is produced. It is best not to have the color too deep, nor should it be very faint. It is best not to attempt to estimate accurately colors deeper than that produced by ·06 mgm. of ammonia in ·50 cc. of water.

Notwithstanding Mr. Wanklyn's assertion to the contrary, I believe perceptible ammonical vapors in the laboratory are decidedly objectionable, and therefore other analyses involving the use or evolution of ammonia or ammonical salts should not be permitted in the same room at the time the water analysis is made.

It is stated that the standard solution of ammonium chloride should never be run into the comparison cylinder *after* the Nessler test has been added because a turbidity is thereby produced which spoils the color estimation. While this is generally true for the addition of more than 1 cc. of Wanklyn's ammonic chloride solution I find that if the comparison test already made is not strong enough it may often be enforced by a few tenths of 1 cc. of the NH_4Cl solution without producing any turbidity at all. Care should be taken, however, to stir very thoroughly with the pipette or the color may not increase perceptibly. Sometimes a peculiar turbidity will occur, however, on the slightest after-addition of NH_4Cl. Conversely, when the comparison test has been made a little too strong, a few tenths of 1 cc. of NH_4Cl solution may be added to the cylinder containing the distillate, so as to make the colors exactly similar, and the amount of this addition is deducted from the amount of NH_3 found in the comparison tube. Greater care must be taken in this case, however, to avoid producing a turbidity since the distillate cannot be replaced without repeating the whole analysis. This method of working economizes both time and the amount of Nessler solution used in each analysis.

For the process of nesslerizing I find it convenient to use cylinders made by being blown from perfectly colorless test-tube glass, free from lead, care being taken that all the set of tubes are of the same diameter (or rather capacity) and that they have good flat or slightly depressed bottoms so as to stand well unsupported. I prefer them to be of such size that 50 cc. of liquid make a column about five inches in height, the tube itself being 15 centimetres in height and 22 or 23 millimetres in diameter. Three dozen of these cost me at the rate of seven cents a piece, and they are all very nearly of the same capacity with only two or three exceptions. A moulded base is very unsatisfactory.

The color is best determined by looking perpendicularly down through the cylinder placed on a white porcelain tile, checking by raising the cylinder vertically an inch or two and observing again, or placing a smaller piece of tile at an angle of 45° beneath it, and also by holding the two cylinders side by side, flat against a white tile held vertically and opposite to the light. The nesslerizing should be done close to a window for which perhaps a northern exposure is best, although this may not be important. I do not at all like Dr. Frankland's method of observing the color of the miniscus by viewing it from above at an angle of 60°. Perhaps I should call this Prof. Miller's method, it being first suggested, I think, by him.

In point of economy of time, a burette holding 15 or 20 cc. is preferable to a pipette for the delivery of the NH_4Cl solution. It may be of the ordinary Mohr pattern, a glass stopcock being both unnecessary and troublesome.

In several cases in my experience the distillates containing the free ammonia had a peculiar odor. In one instance where the free ammonia was very large the distillate possessed what may be described as an "earthy" odor. In this case the albuminoid ammonia was remarkably small in amount. Tidy's permanganate method also showed an extremely small amount of oxidizable organic matter. To this case I shall have occasion to refer at a future time.

In another case of the water of a terribly polluted well, situated in the basement of a residence, on distilling with sodic carbonate a strong, disagreeable odor was noticed in the free ammonia distillate. This odor was similar to, but more intense than, the odor which the water itself possessed on being warmed. The free ammonia was 2·860 parts and the albuminoid 0·512 parts per million. The chlorine, nitrates and total solids were all very low in amount. Sewage contamination was therefore improbable. The color of dilute permanganate was, however, discharged rather rapidly. The water had an opalescent, or whitish, appearance in a flask, and there was a large amount of floating sediment of a fungoid character of very peculiar appearance as shown under the microscope. Some of these masses were groups of regularly distributed white opaque spheroids, while one resembled nothing better than a fragment of the most delicate white floss of fine filaments massed together in a dense white mass nearly as broad as long. I can find no illustration of microscopic fungi at all closely resembling these substances. The special point to be considered just

now is the odor occurring in the free ammonia distillate. It seems very probable that this was due to organic matter which volatilized unchanged on boiling with sodium carbonate, and although condensed with the free ammonia was not estimated as ammonia, and was consequently lost in the analysis. This appeared to me to be the explanation at the time of the analysis, October, 1880. It did not, however, occur to me at the time to repeat the distillation with alkaline permanganate alone for the total ammonia, as suggested by Prof. Remsen of Johns Hopkins University, and also lately by Mr. Marsh, of Princeton College, in a paper in the *American Chemical Journal*, Vol. iv, No. 3. The authors have shown that there is frequently a considerable discrepancy between the added free and albuminoid ammonia determined separately and the total ammonia developed by distilling with alkaline permanganate alone. The latter being always in excess in these cases, seems to indicate a frequently occurring loss of volatile organic matter in the ordinary distillation for the free ammonia. Hence, it would appear advisable always to repeat the distillation in this manner so as to check the results.

On July 17th of this year I collected myself a sample of water from the fore-bay of the Fairmount Water Works at a point under the stone bridge, and collected at arm's length below the surface of the water. The results of analysis were as follows:

Free ammonia, ...	½ litre used:	0·150	mgm. per litre.
Albuminoid ammonia, . . .		0·110	" "
		0·260	" "
Total ammonia by permanganate,	¼ litre used:	0·264	" "
Difference for volatile matter, ...		0·004	" "

This difference is, however, clearly within the limits of error of nesslerizing, and can therefore be rejected, and it is safe to assume that there was no volatile organic matter present in this sample of Schuylkill river water. It would have been better to have used at least a half litre for the total ammonia, but the amount of the sample collected did not admit of it, since the rest was used for the estimation of the oxygen required to oxidize the organic matter by Wanklyn's "moist combustion" method, as described in the fifth edition of his Manual. This gave the oxygen required by moist combustion to be 3·75 mgms. per litre. This oxygen required for the Schuylkill water

has been found to vary at different times from 2·75 to 3·75 mgms. per litre.

The sample was collected about 10 o'clock A. M., a couple of hours after the fore-bay had been raked free from the grass and rubbish, as is done every morning. The water was not flowing over the dam, therefore, the analysis represents pretty fairly the average condition of the river at Fairmount on that day. A sample collected at the same time at the entrance to the fore-bay gave very nearly the same results.

At the time of this analysis the thorough dredging and cleaning out of the fore-bay of Fairmount Works, as recently determined upon by the City Councils, had not yet been commenced.

It may perhaps be shown by future investigation that the differences in the ammonia supposed to be due to volatile organic matter may more frequently occur in the analyses of well waters than of river waters.

REPORT ON EUROPEAN SEWERAGE SYSTEMS, WITH SPECIAL REFERENCE TO THE NEEDS OF THE CITY OF PHILADELPHIA.

By Rudolph Hering, C.E.

(Continued from page 303.)

V. Junctions, Connections, Overflows and Outfalls.

The remaining features of the sewers requiring consideration are their separate termini or the points of reception and discharge. Generally speaking, they should enable the sewage to enter and to discharge, so that no detention, irregular flow, eddies or backwater are caused, as all of these disturbances produce deposits which it is the first object of a perfect system to avoid.

(*a*) Junctions.—When two or more sewers join to form one, several designs can be used, according to circumstances.

As junctions presuppose a change of direction, and as this may retard the velocity, its effect must be reduced to a minimum or counterbalanced entirely. The latter can be done by decreasing the angle as much as possible and by a corresponding increase of gradient. The amount of fall available, therefore, will govern the least radius of curvature advisable. The following are the formulæ which were

generally recommended to determine the relation of the degree of curvature and the additional fall.

$$h = \frac{a.\ c.\ v^2}{579{\cdot}4}\ (\textit{Weisbach.})$$

$$h = \frac{v^2 \sin^2 a \times 0{\cdot}000{,}003}{\sqrt{r}}\ (\textit{Robinson and Beardmore})$$

$$c = 131 \times 1{\cdot}847 \left(\frac{r}{b}\right)^{\frac{7}{2}}$$

h = additional fall to overcome friction.
v = velocity in feet per second.
a = angle in degrees.
r = radius of sewer.
b = radius of bend.
c = coeff. depending on $\frac{r}{b}$.

Junctions of large sewers are usually covered by funnel-shaped arches. In England, Frankfort and Hamburg these are almost exclusively used. In Berlin and Paris cylindrical arches and rectangular chambers are preferred, although as a rule, they require more material and offer a much greater chance for deposits. An important feature of a sewer junction is the tongue, forming the terminus of the walls between two sewers which, gradually diminishing in section, are extended into the chamber. Its purpose is to fill by masonry or other material that portion of the space which is not necessary for the flow of sewage and which otherwise gives a cause for eddies and deposits. The design is obtained by simply extending the lower half of two adjoining sewers, until they naturally intersect. The ridge, which is thus formed, runs out to a point at the bottom and is usually capped by dressed stone, neatly rounded.* With these tongues, deposits cannot occur at a junction any more than in the sewer.

Pipe sewers which, on the Rawlinson principle, should be straight between two points of access, must make their entire turn within the man-hole, half-pipe curves often being placed in the bottom. For these short turns a extra fall is of course necessary. When pipes are joined in a man-hole it is much better to carry them through in half-pipes, without a drop or break, than to adopt the "pot and pipe" system, as in Danzig, where the man-hole acts as a basin for deposit.

* See Appendix No. 4, Pl. VI.

A word must be said regarding the relative heights of joining sewers. In order that two streams of sewage may unite and continue their course without retarding the velocity, either below or above the junction, it is necessary that the surface of the water in each should be at such relative heights that backwater is not caused in any branch. The smaller sewers, therefore, require adjustment to the larger ones. This may be done in two ways, either by so narrowing and shaping the smaller branch that the height of water from the same rain-falls would rise about to the same height as in the larger one, or by simply raising the former so much above the latter that the same result is attained. The first plan is seldom necessary, and is more expensive and difficult to construct than the other. To carry out the principle to a nicety in each case very often requires a difference of elevation which is not practicable, therefore it is best to consider not the height of the storm-water flow, but only the ordinary stage of water (existing about $\frac{9}{10}$ of the time) when the sewage alone is flowing in the sewer, and to design the junction so that it will answer this case. In other words, the branches should be at such elevations that the *ordinary* flow in the smaller sewers is at least at the same level as that of the larger ones. This precaution is frequently but not generally carried out in Europe. In Frankfort it has been most carefully considered.

In Philadelphia, sewer junctions have not been made according to any system. Three feet sewers are joined often without a substantial arch and without a tongue to prevent deposit. Often they unite at right angles or nearly, so that an obstruction and backwater must occur during heavy rains. Large sewers are joined at better curves, but also without a tongue, and their relative heights are not unusually adjusted, so that the inverts are on a level, causing backwater in the smaller one.

The direction of improvement is therefore indicated.

(*b*) Connections.—By connections I will designate the junction of the house-pipes with the common sewer.

The comparatively small amount of water they carry does not give them the same importance as the junctions of large sewers, yet the same principles govern. The water from the house should be discharged so that it will not impede the flow of the sewer, and it should itself not be subject to permanent backwater.

In the modern works in Europe great care is taken in giving the connections an angle of about forty-five degrees or less in the direction

of the flow. While sewers are being built, the connections are provided for at once in nearly all the towns, and if not immediately used, they are temporarily closed. At some places the city builds the house connection to the inside of the front wall of every house, as in Berlin; at others, to the curbstone; at still others, only through the sewer. A "Y" branch for pipe-sewers, and a slant pipe or a block of terra-cotta or of cement for brick and concrete sewers is inserted opposite each property in every case.

In Philadelphia, it has become customary, within the last few years, to place the connection-pipes into the sewers while these are being built. It has been done consistently only with the main sewers. The others generally receive them only where immediately needed, and then in rare cases they have been made properly. Formerly, when a house was connected, the sewer was broken into, a pipe often carelessly inserted and left to project into the sewer. Many breaks during storms have been traced to such imperfectly made house connections. Now, either a straight pipe is inserted at right-angles to the current or a "slant" pipe. The latter, too, is commonly placed at right-angles, making a vertical instead of a horizontal angle, which entirely defeats their real object.

To prevent a retardation of flow, the connection piece should therefore be built into the sewer firmly and accurately with no projection whatever. It should be placed at an acute angle to the flow, and to prevent back water the velocity of the entering water should, if possible, be greater than that in the larger sewer.

(*c*) Overflows.—Economy demands that rain-water after entering sewers be led into natural channels, as directly as possible, unless this is objectionable for some reasons, instead of having large underground works for the purpose. When purification is required, it is likewise necessary to relieve the sewers of the greater part of the rain-water. Overflows, therefore, must be constructed at certain points from which the water, when it becomes sufficiently diluted, can escape into a river or creek. But this can be done only where the sewers are intercepting, not, of course, where they themselves take the nearest course to a natural outfall.

As our city has no intercepting sewers where the consideration of overflows is of any moment, these remarks apply only to their future use, which, however, cannot be very distant. When it will become necessary to prevent the sewage from flowing into the Wissahickon and

Tacony creeks and into the Schuylkill and Delaware rivers along the wharves of the city, storm-water overflows will have to be built in order to decrease the size of the intercepting sewers.

They are a very common contrivance in Europe,* and generally consist of a wide shallow opening at the side of the sewer to be relieved, placed at such a height as will insure to the overflowing water the degreee of pollution permitted, and not subject the sewer itself to an unsafe internal pressure. An overflow must be wide and shallow to provide for a sufficient bulk of a thin sheet of water running over, and it is then gradually reduced to a circular or egg-shaped channel, in which the water is carried to the rivers. When the intercepting sewer runs entirely below a crossing valley-line sewer another device is generally used by which the ordinary flow of sewage drops into it through an opening, but the storm-water, having a greater velocity, leaps over and continues its course.

The location of overflows is mostly at old valley-line sewers which are utilized for the purpose, or they may be at any other convenient point.

(*d*) OUTFALLS.—The proper point or points of ultimate discharge of a system depend on several conditions. First, when the sewage is to be purified, the outflow must be at the locality where this is to be done, and at such an elevation as will command its distribution. Secondly, when the sewage is to be discharged into a water-course, the outfall must be situated so that the discharge will be effectual, and so that it causes the least possible nuisance.

The first case needs no consideration, as the Philadelphia sewage can be discharged into the Delaware at outgoing tide for a time longer than would demand consideration at present.

The second case is treated in Europe as follows: In London the sewage is taken ten miles below the city to the banks of the Thames. There it is stored in reservoirs during incoming tides and discharged into the river at and after high tides. In Liverpool the sewage is discharged into the Mersey from nine outfalls in front of the city, outside of the docks and above low water. The ordinary tide ranges 21 feet, and the current is swift, so that the sewage is dispersed very quickly. In Hamburg the discharge is into the Elbe, opposite the city, by means of a few main and intercepting sewers. They are extended into the current by submerged conduits on the bottom of the river.

* See Humber on Metropolitan Drainage and Appendix No. 4, Pl. VIII and IX.

The other large cities either require purification or are in a transient condition.

In stating what outfalls are required for Philadelphia, a discrimination must be made between what is needed at present and in the future.

As I will speak of the latter further on, the first shall only be considered now.

The present outfalls into the Schuylkill and Delaware rivers are at very different elevations and positions. Some are below low-water and range to others above high-water; some are at the head of the piers and others in the docks.

When it becomes necessary to intercept the sewage the elevation of these outfalls will have an important influence on the cost of so doing, and it is well, therefore, to consider this subject in advance, so that they will suit an ultimate system. Apart from it, the following points should be held in view: In order to have a complete discharge of the sewage at certain intervals, outfalls of the valley-line sewers should terminate at an elevation which admits of the surface level of the ordinary flow of sewage being above mean low tide. In order to have the most effectual discharge of storm-water its hydraulic gradient should be regulated with regard to the highest tides.

In other words, sewers of an effective vertical diameter *less* than our tidal range (six and a quarter feet) should be adjusted from the high-water mark, sewers with a *greater* effective diameter from the mean low-water mark.

If adherence to this principle is not possible at the wharf line, it is possible and should be carried out at a short distance from it, and the outlet can then even be entirely submerged.

It may become advisable at some points to lead the sewage into the current away from the shore, and for this purpose a submerged outlet below the reach of the keel of large vessels is practicable and efficient, as in Hamburg and in a few other places, being simply of framed timber loaded and anchored to the bottom.

As heretofore, I must now refer to these structures, as applied to the *separate* system.

Junctions of sewers carrying sewage alone, require no different treatment from that indicated; the same principles apply to the sewers proper and are also suitable for the rain-water channels.

This can also be said of house connections. An acute angle is even

of greater importance in this case, because the velocity in a small sewer can be more readily affected by its retarding influence than in a large sewer.

Overflows do not occur in the separate system except at pumping stations, where they are always provided for, to operate in case of accident.

Finally, outfalls of the separate system must answer the same requirements as those of the combined. The rain-water channels, if they receive only rain-water, can of course have outfalls at any place, without causing a nuisance.

It is necessary yet to state any special features which concern the *construction* of junctions, etc.

After what has been said in the previous part, it must be added that the care which was considered necessary in the selection of material and labor for the sewer proper is even more necessary here. The strains upon the work may be greater and. therefore, require additional strength. The irregular movement of the water will require neatly finished corners, surfaces and edges to avoid eddies or retardation and deposit.

The tongues in junctions should be made of dressed stone or moulded in concrete. The house connections should be made by blocks, either of terra-cotta or moulded in cement, in preference to using "slants," because the brickwork can not be as readily fitted to a round pipe.

VI. Appendages to Sewers for Inspection, Ventilation and Flushing.

It is now in place to examine the appendages to sewers which are to facilitate their maintenance. They are the means for access, for a thorough circulation of air and for cleansing.

(*a*) For Inspection. *Manholes.*—From the uncertain and irregular nature of the substances that enter sewers it is necessary to be able to inspect or have access to them, so that the nature and place of any obstruction can be readily determined and the object removed. Manholes and lampholes or inspection shafts are built for this purpose. The latter are used only on pipe sewers, and alternate with manholes. A lamp is suspended in them, at times of examination, which can be seen from the latter and thus reveal any imperfections. They are much used in England.

In Philadelphia, manholes only are built because pipe-sewers have been seldom used. They are vertical shafts circular in section and covered with a grating, which again is covered by a sheet-iron hinged lid. During the last few years open gratings have been occasionally used to permit ventilation. Wrought-iron ladder-bars have sometimes been built into the shaft.

In Europe different designs are found in different cities. In some the shaft is circular in section, in others it is square. The former is to be preferred, mainly because it is more economical. Steps are always built into it, and are generally of cast-iron, which does not rust as easily as wrought-iron. In frequented streets it is a general custom to enter the sewers from the sidewalks by means of a so-called side-entrance, in order not to disturb the travel. In others, manholes are placed directly over the sewer. In the former case, a double cover is used, consisting of a tightly fitting lid, flush with the pavement and a grating immediately below it. When examinations are made, the lid is left open and locked, while the grating prevents danger to pedestrians, and admits air and light.

When manholes are in the street they are almost always provided with means for ventilation. For this purpose the cover is often a grating. To prevent street dirt from dropping through into the sewer different provisions are made. In Berlin, a sheet-iron plate is placed a few inches below the grate, the latter having holes around the periphery, while the former has them in the centre. It is lifted out and cleaned every few days. In some towns, where the gratings are open in the centre, there are buckets suspended under them to catch the dirt and which are periodically lifted out and emptied. In England there is generally a small catch-basin to one side of the manhole, with a side opening between them. In this case the manhole has a closed cover and the catch-basin a grating.*

To determine the proper design for Philadelphia is somewhat difficult, as the conditions are very dissimilar.

In Europe, every large city has a well organized and trained body for a regular and systematic inspection, flushing and cleaning of the sewers. The latter are, therefore, seldom foul nor is the escaping air objectionable; and the catch-basins, buckets or plates, can be regularly freed from their dirt.

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* See Appendix No. 4, Plates I and IV to IX.

In Philadelphia there is no such body and the sewers are only entered, either for repairs, or when an obstruction is sufficiently great to entirely impede the passage of the sewage. The only regular cleaning done is the emptying of the inlet-basins. Entrances on side-walks would not be advisable in Philadelphia, because the obstruction in the street, when using common manholes, would not be likely to give much cause for complaint and mainly because the sidewalks are private property.

To facilitate ventilation, of which I shall presently speak more fully, a direct communication from the sewer to the street has been found to be of great importance and should be gradually introduced wherever it does not cause an absolute nuisance, in which case less effective or more costly provisions are necessary. Manholes ought, therefore, to be ventilating as much as possible, and, what concerns us at this place, should be provided more generally than heretofore, with a grating instead of a closed cover.

In order to avoid the street dirt from dropping through such gratings into the sewers, which is as important as preventing its entrance through the street inlets, the simplest and most convenient arrangement is to have a pan or bucket hinged to one side of the cover and resting with a projection on the other, with enough space around it for the air to escape. The grating then would have holes only in the centre above the pan. Whenever the streets are swept, it would be a simple matter to lift up the gate and swing the pan over, which would throw the contents on the street.

Finally, I would suggest that cast-iron steps, or foot-irons, be built into every manhole, so that a permanant and easy means of access may be had.

With these points receiving attention, I trust that our manholes would better answer their purpose. The details of construction as used in other cities will be seen from the accompanying drawings in Appendix No. 4.

The distance which manholes are apart also varies in different localities. Generally, experience has shown that for small sewers there should be two in one of our squares, or about two hundred to two hundred and fifty feet apart. For large sewers this distance can be much greater, unless they are required for ventilation.

Lamp-holes.—Where pipe-sewers are built, a manhole may be saved at certain points by inserting a vertical pipe, covered with an iron lid

or grate, and into which a lamp may be lowered from above. Care must be taken to prevent dirt from dropping into it, which is best accomplished by a small catch-basin at the top, with the pipe projecting in its centre and the gate openings around the periphery.*

(*b*) For Ventilation.—The question of ventilation is one which is of paramount importance to a sewerage system, in order to keep it in a sanitary condition, and it is one which has received much greater attention in Europe than here. In comparatively few instances we have placed open manhole covers in the streets, to allow the escape of gases, but this, although relieving the sewer of any pressure, has sometimes rather caused a nuisance, on account of strong exhalations.

A great deal of discussion has been had upon the arrangements essential to a proper ventilation, but the matter can, I think, be narrowed down to the following points.

The changing quantities of sewage and rain-water, and the difference in the temperature of the sewer-air and the atmosphere, produce corresponding changes in the quantity of air contained in the sewers, which will consequently sometimes be drawn in and sometimes expelled. Provision must be made for this pulsation, because otherwise the numerous water-traps connected with the system will be forced, in order to establish equilibrium, and the sewer air can then enter the houses.

There are three effectual ways of accomplishing the free exchange of air. Either special shafts are constructed to a height which will enable the air to disperse unnoticed, or openings to the sewer are provided in the roadway, or, thirdly, the soil-pipe of every house acts as a ventilating shaft, not only for the house system but also for the sewer. Any one, two or all of these methods are used in Europe.

Special shafts have been built in some towns, notably Brighton and in Frankfort-on-the-Main. Unless circumstances are peculiar, such shafts are not only expensive, but their effect is not in proportion to the cost over simpler contrivances. They have, therefore, not been used in new works as a rule. Street gas-posts have been suggested as ventilators, have been tried but almost entirely abandoned. Only one instance, in Glasgow, where a sewer was ventilated in this way came under my notice. Air for factory furnaces has been drawn from sewers, but this has likewise been abandoned, except in isolated cases.

Openings into the street, after trials in a great many places and during

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* See Appendix No. 4, Pl. IV.

many years, are now considered not only the most effective ventilators, but also not in any way objectionable if the sewers are kept in a proper condition, as they always should be. With hardly an exception, they are used in every drained European city, and give no cause for complaint. The inlets also, as already mentioned, are not trapped and assist ventilation in certain cities, as Paris, Hamburg, Leeds, Berlin and occasionally in London. But generally, it is preferred to limit the openings to the middle of the street, because the inlets, being at the footpath, could more readily annoy persons by any exhalations, especially when the cleaning of sewers is imperfect. Charcoal and various chemicals have sometimes been placed in manholes and other ventilating structures to purify the air by letting it pass through or over them. But these methods are rarely used any more, because the expense is generally disproportionate to the benefits derived from them.

Finally, ventilation of sewers through soil-pipes is used extensively, if not wholly, in continental towns. The odor arising from matter discharged in the house alone is generally stronger than the effluvia arising from the sewer, and if the soil pipe is secure against the former, it is certianly safe against the latter. An objection to this, although sometimes raised, can hardly be substantiated in view of the satisfactory experience in the continental towns. In order to ventilate the soil-pipes alone there must be a lower as well as a higher opening. Then, too, it seems better to have it in the sewer than at the pavement, where an occasional down current would be noticeable.

It is advisable, however, to have both street openings and soil-pipe ventilation. By this means the air may either be drawn into the former and up the soil-pipes, when, as is mostly the case, the temperature in the latter is higher, or it may be expelled from both during a sudden fall of rain, and again drawn in when the water lowers. In the latter cases, the street openings would act almost alone because of a more direct communication with the air and in giving less frictional resistance to it, but otherwise and especially in small sewers, and during the winter when snow is on the ground, the draught up the soil-pipes would be of much benefit to the system.

I believe, from the impressions gained, that this method of using both soil-pipes and open street gratings, carefully designed, is destined to become the most acceptable one for sewer ventilation, because it gives free circulation at all times with the least objectionable features. Yet

it could not be recommended for our city without certain concurrent changes.

The stench arising from our sewers is unusually strong. It is not only caused by their average foul condition but very often by the filtration into the sewer of illuminating gas from leaky pipes. That the latter circumstance is exceedingly common is attested by an examination of the odor arising at summits, and by one or two explosions every year, which upon investigation, have heretofore always turned out to be caused by leaks in the gas mains. With filth lodging in the sewers as a permanent producer of foul odors, and the frequent leaks of illuminating gas, ventilation into the street would be a nuisance at many if not at all points. But with these two points removed, the odor in sewers is not disagreeably strong. It is not noticeable at the surface, except within a few feet of the point where it escapes, and where it is even slight and in no way objectionable.

This condition is the common one in the best drained cities of Europe, from the impressions I received in walking through many miles of new and old, large and small sewers.

The lodging of filth and the leakage of gas into sewers can be avoided: first, by adopting a rational section, size and grade, which will reduce deposits to a minimum; secondly, by not laying gas pipes through or too near the sewers, which generally strains the joints, or breaks them; and thirdly, by a periodical inspection to discover irregularities before they become formidable and when they can be readily corrected.

Such demands are simple, reasonable, and cause no greater expense than is willingly granted in Europe, where a long experience has established their importance and ultimate economy, not only for the purpose of facilitating ventilation, but for the general sanitary condition of the works. And in so far as they could be satisfied also in our city, the conditions of the sewers would become improved, and their ventilation made easy, thorough and inexpensive; any other method, as far as I could learn, would be less perfect and and more expensive.

It is therefore to be recommended that man-holes and lamp-holes be covered with a perforated grating as soon as and wherever the condition of the sewers will permit of it. They should always be placed as far from the sidewalk or crossing as convenient. It is further to be recommended that soil-pipes, as soon as their perfect construction can be guaranteed, should act as ventilators not only for house-pipes, but

also for the sewers. For this purpose they should have as direct a course as possible, and terminate above the roof with full size, and be trapped against every branch pipe in the house, but not against the sewer.

Before leaving the subject, I am obliged to call attention, at this place, to a cause which can seriously affect the condition of sewers. As decomposition is furthered by moisture and warmth, it is evident that whatever will increase these conditions beyond an unavoidable point, increases decomposition and the foulness of the sewer. Exhaust steam, for instance, when discharged into it, does this in so great a degree that the effect can readily be noticed in all localities where this is permitted. I found quite frequently ordinances prohibiting the discharge of steam and requiring condensation, and some American cities have, I believe, similar legislation already.

As this custom naturally would have the same effects here its further extension should be deprecated as much as possible.

(*c*) For Flushing.—Under this head it necessary to speak of contrivances that we do not yet possess. A few words must, therefore, be said on the importance of flushing sewers.

A deposit of solids can never be entirely prevented in a sewer, no matter how good its shape and grade may be, because of the very nature of sewage. Therefore, an occasional examination and the removal of retained and obstructing matter is necessary. Flushing is a means by which nearly all ordinary deposit can be removed at a small expense comparatively, and which is employed in all of the well drained cities of Europe, with one exception, viz., Vienna, where, however, arrangements are being made for the early introduction of the same. A sewer is flushed by sending a sudden gush of a mass of water through it at a quick velocity, which stirs up the sediment, suspends it in the water and carries it along. To obtain this mass of water is in no case difficult, for the sewage itself will answer the purpose. Nothing has been found more effective and more economical than such a regular flushing of a sewer. Its importance is therefore apparent, and its introduction in Philadelphia would be of great value towards raising the sanitary standard of our sewerage. Practical obstacles, however, would not permit this at once, as our sewers are not designed with reference to flushing.

The circular form, where the ordinary sewage spreads only over a small segment, requires a much greater amount of flushing water than

where it is confined to a semicircle, as in an eggshaped sewer. The three feet circular section ordinarily would require the same amount of water for flushing, if it drains two houses or many hundred, because it must be filled to a certain height to have any effect, and because a three feet sewer draining but a few houses is much more liable to accumulate deposit, than one having a large stream of sewage constantly flowing through it.

It is, therefore, evident that for flushing purposes also, the size and shape of most of our sewers is not the best. Yet notwithstanding, as there is no other method known of cleaning sewers, which could take its place under our present conditions and which would be as simple, effective and economical, attention should be given to its early introduction.

The appliances used in Europe are briefly stated as follows: small pipe sewers up to nine inches in diameter are flushed, as in Liverpool for instance, by attaching a hose to a fire-plug and running a stream into a shaft at their upper end; or, the chamber often built at the head of a sewer is filled with water from a plug or tank, after its outlet is closed with a hanging flap-valve, which when subsequently raised allows the water to rush out through the pipe.

Manholes on the line of pipe-sewers can be similarly used by having flaps for each pipe. After the shaft is filled with water, then, by raising the flap from the sewer to be flushed, the entire contents are sent through it. For brick sewers, gates of iron or wood are often used. They swing on a vertical axis at the side, and close across the sewer, enabling the sewage to accumulate behind them, and to be suddenly released. Penstocks, moving vertically by means of an endless screw worked from above the sewer, are likewise common contrivances for the larger sewers.

These appliances are neither costly nor difficult to manage. Their location and distance apart depends on numerous conditions. As a rule, they are placed just above a point where the most sediment occurs, and not closer together than necessary to get the full effect of the flush, which depends on the grade and the size of the sewer, and needs a special examination in each case.

Flush-tanks, the best being those of Mr. Rogers Field, are also good contrivances for flushing, but they are confined to the use of clean water and to small pipe sewers, therefore are adapted only to the highest parts of a sewer.

In conclusion, I cannot too earnestly recommend from the good effects observed from it in Europe, that flushing should be gradually introduced in our city, wherever practicable, to free the sewers of their deposit before it accumulates to an extent which causes them to get foul

The appendages to the sewers, as thus examined, do not require much modification, if used for the *separate* system. Manholes and lampholes are equally important, if not more so, because the sewers cannot be walked through. The size, shape and position need not be different from those for the combined system.

Ventilation is also had in the same manner. Both sewage and rain-water systems, however, require it; but the latter does not need as frequent openings, because the air cannot get so obnoxious.

Also with regard to flushing, nothing further need be said, except that it becomes more necessary and important as the pipes decrease in size.

VII. General Alignment of System.

I have now followed the subject to a point where it becomes necessary to inquire into the future development of the city and its demands.

To examine into the general alignment and probable extent of our sewerage we must know in what directions the city is growing, as this can materially affect present works. It is also necessary to know the probable character of the outlying districts, in order to decide where the separate or the combined system is most suitable.

To determine upon these questions in detail will require a close and careful study. Only some general points can be given at present, and the direction indicated in which furthur inquiry is necessary.

I shall first allude to the systems of alignment as employed in Europe and then endeavor to adapt some of the results to our own city.

The growth of the cities, the topography of their sites, as well as the existing sewerage works at the time of the construction of a complete system, have all influenced the designs. A great diversity is therefore natural.

London has a complete system of valley line sewers, which follow closely the natural flow lines of water from the surface. In addition, it has the Main Drainage Works, a system of intercepting sewers, which prevents the sewage from entering the Thames, and takes it to a point ten miles below the city and there discharges it into the river at outgoing tides. A portion of the sewage thus intercepted flows off entirely by gravity. The greater part requires to be pumped; a small

portion is even lifted twice before it reaches the outfall. Although the main drainage sewers are capable of taking some rain-water,* most of it reaches the river directly through the valley line sewers into which the intercepting sewers discharge their surplus during storms.

The general alignment in Paris is partially an intercepting and partially a valley line system, owing to the topography. The sewage is discharged into the river below the city. The irrigation fields, now in preparation, receive about one-fifth of the whole amount. A small portion reaches them by gravity, the rest is lifted nearly thirty feet. The sewage from the higher grounds is intercepted so that it will not flood the lower ones during heavy storms. The sewers along the banks of the Seine are also intercepting.

Berlin has a peculiar system, due to its flat position and the necessity for purifying the entire sewage. The latter is to be collected at twelve different points, to which the sewers converge radially and from each of which it will be pumped directly to the farms.

Vienna has a natural valley line system, except two intercepting sewers, along the banks of the Wien Creek flowing through the city.

In Liverpool, the sewers partly follow the natural slopes, and partly cross them where it is necessary to intercept the storm-water. The sewers finally discharge directly into the Mersey, in front of the city.

In Hamburg, intercepting sewers predominate on account of the necessity of keeping the sewage out of the numerous canals and the Alster lakes. The sewers discharge finally into the Elbe, in front of the city.

In Frankfort, the low grounds near the river made an intercepting system preferable, and it has been carried out in a consistent manner over the whole city. Rain-water overflows, however, lead to the river directly from many points. The intercepting sewers discharge below the city.

From a study of the alignments in these cities† it will be noticed that the system of interception is made use of, partially to prevent an undue accumulation of rain-water at the foot of slopes, partially to prevent sewage or rain-water from flooding low districts, and partially to prevent sewage from flowing into the rivers in front of the cities.

A more detailed study will further reveal that an early concentration of sewage into a few larger sewers is preferable to keeping it more

*An amount equivalent to a fall of one-quarter of an inch in twenty-four hours.

† See Appendix No. 5.

uniformly distributed over the area in a number of smaller ones, and a calculation will show the economy of this.

Finally, it will be clear that the manner of disposal of the sewage depends on the body of water flowing by or near the city. The Thames is capable of receiving the London sewage without injurious effects. The Seine, being much smaller and very far from the sea, is objectionably polluted, and the sewage is therefore to be purified on the sandy plains of Gennevilliers below the city.

Vienna discharges its sewage at present into the Danube canal, but is preparing to lead it into the Danube itself, the capacity of which is sufficiently large to prevent any pollution.

Berlin has but a small river flowing by it, which makes purification of all the sewage a necessity.

Hamburg and Liverpool are situated along large bodies of water and discharge into them without objection.

Frankfort discharges into the Main, but steps are now being taken to purify the sewage, as the danger of pollution by the rapidly growing city is fast approaching.

In Philadelphia, we have two rivers into which the sewage is discharged. The Schuylkill river is small and its dry weather flow can be easily polluted. And it forms, also, a tidal basin opposite the heart of the city, headed by the Fairmount dam, which causes sewage to deposit its heavier matter more readily than in a running stream. The Schuylkill, therefore, should not finally be a recipient of the city's sewage. A certain quantity, of course, is admissible, and this should be determined at an early day. The magnitude of the Delaware river, however, is such that we need not fear any effects of its serious pollution within a space of time which it is reasonable for us to consider at present.

It may be well to re-state at this place that the utilization of sewage, which has now been experimented upon both in England and on the continent for a long number of years, is invariably connected with additional expense to the community instead of profit, except under peculiar circumstances, such as Philadelphia does not furnish. Yet where it is necessary, for sanitary or other reasons, to prevent the pollution of streams or other bodies of water, the cost of purifying sewage is justified. As in Philadelphia this necessity does not arise, purification of sewage will not be required, and our general alignment need not be made with reference to it.

The discharge of sewage into the Delaware must, however, be subject to the precaution that it shall not cause a deposit of filth and silt along our wharves. This can be effected either by taking it out into the channel by means of submerged sewers, as in Hamburg, or by storing it during the incoming tide and discharging it after high water, as in London. The first will probably do for a long time, the latter will ultimately have to be resorted to. To determine a proper location for an ultimate outfall requires a careful study. A few conditions can here be stated. First, the point must be below the city, so that the sewage is prevented from polluting the shore lines. Secondly, as much sewage as possible must be taken to the outfall by gravity and not require pumping.

With these two points considered, representing the sanitary and economical side of the question, we can readily determine some several features of a future system of sewage collectors by examining the topography of the city.

Some time ago, I sketched out a general alignment,* having these same points in view. As I cannot at this time, in comparing it with the alignment in the above cities, see any reasons for deviating from the general plan there set forth, at least as far as the near future is concerned, I shall consider it as embodying what I would now recommend and therefore not enter into the details at this place.

Two intercepting sewers, I concluded, will become necessary at an early day: One, the Manayunk sewer, to keep sewage from entering the Fairmount pool and polluting our drinking water, another from polluting the docks along the Delaware. The remaining sewers would not be needed for some time, but their best location and grade should be determined in order to bring the valley line sewers crossing them hereafter to a proper and suitable gradient.

I must now add two more intercepting sewers, also deserving of consideration at an early day, namely: First, the intercepting sewer, which is to prevent the sewage of the north-eastern part of Germantown (Wingohocking creek) from polluting the Frankford creek, which may temporarily be discharged into the Hart creek sewer. Secondly, the sewer which skirts the south-western part of Germantown and which can temporarily discharge into the West Cohocksink sewer, or, if it is already built, into the Manayunk sewer at the Falls. By it the remain-

* Proc. Engineers' Club, Vol. II, No. 1.

ing part of the Germantown sewage can be intercepted and prevented from flowing into the Park, the Wissahickon creek and the Schuylkill river above the dam.

Germantown and Chestnut Hill are, I think, without having made as close an examination as it will require, well adapted for the application of the separate system; and an early study of the matter is advisable in order to regulate the construction of sewers already going on in the district. With the separate system applied in that locality, the rain-water can flow, as at present, into the Wissahickon, but the sewage alone could be carried in a small sewer, less than 4 ft. diam., across the water-shed and discharge into the West Cohocksink.

Regarding the general alignment nothing further need be said. But the detailed alignment requires a few more words.

As a rule, the sewers in Philadelphia are laid in the centre or on one side of a street. The house branches in broad streets are therefore rather long, or if on one side, unevenly long for the properties on the two sides. To avoid this, it is customary in nearly all European cities to build a sewer on each side of the street, under the gutters or the sidewalks, whenever its width exceeds a certain measure, usually 60 to 70 feet. We have few streets exceeding this width, but it would be well in these few to lay two sewers, not only for the reasons just mentioned, but to avoid the frequent breaking up of the pavements, which are generally of a better class in wide streets and are seldom perfectly replaced after house connections are made, and because it is often more economical for the property owners.

Another point deserving consideration is the avoidance of a sudden decrease of the gradient, by which not only deposits occur, owing to the decreased velocity, but in many cases a flooding, as the hydraulic gradient during heavy rains is likely at such points to rise far above the sewer. In London and other places this effect has clearly been shown. To avoid it the alignment should be made so as to have an intercepting sewer near the foot of a slope, as can clearly be seen in the maps of Paris and Liverpool,* and to gradually decrease its grade.

Alignments should further be made so that a free discharge is possible during high water. Partial interception is resorted to for this purpose, in the case of low-lying valleys, as in London, Paris, Hamburg and other places. In our city, the Cohocksink valley offers this

*See Appendix No. 5.

feature. Instead of permitting the sewage of high parts of this area to flow into the valley with a comparatively heavy grade, and then to continue its course with a very light grade, which may at times of high water entirely vanish, it is both more efficient and economical to intercept as much sewage and rain-water as possible, in order to discharge it freely at high water, and to confine the low valley line sewer to the comparatively small area, which cannot be intercepted. Examples of this method of treatment are found in nearly every city I visited.

Finally, it is necessary to state that the alignment of the main sewers becomes most important when a city has reached dimensions like those of Philadelphia. The continual extensions of sewers in every district make it a matter of great economy to determine early upon an ultimate and uniform system, to which all present works will in future be subservient. Every large European city has its general system fully worked out, as have also several American cities, and the question is no less important for us.

It will not be necessary to enter into the minute details as yet, but simply to establish the alignment, depth, grade and size of the principal intercepting sewers required in the future, so that, when additions to or alterations of the present works are made, it is all done to suit an ultimate system.

Because the question is one of many difficulties for this city, on account of the large extent and varying characteristics of the drainage areas, an early study is only the more imperative.

Herewith I conclude my remarks with reference to the various parts of sewerage systems in general and detail, having a bearing upon our own needs. It will now be necessary to devote some remarks to the management and cost of works.

(To be continued.)

The Telephone in the Fifteenth Century.—Leonardo da Vinci makes the following statement: When one is upon a lake, if he puts the opening of a trumpet into the water and holds the point of the tube to his ear he can perceive whether ships are moving at a remote distance. The same thing occurs if he thrusts the tube into the ground. Then also he will hear what is going on at a distauce.—*Beiblätter*, vi, 190. C.

EXAMINATION OF WATER AND AIR FOR SANITARY PURPOSES, WITH REMARKS ON DISINFECTION.

By Romyn Hitchcock.

[A paper read before the American Association for the Advancement of Science. Montreal, August, 1882.]

It is not my purpose in this note to bring before you any new discovery or observation, but rather to call forth an expression of the opinion of chemists who have been engaged in examinations for sanitary purposes. The question I propound for discussion is this:

Under what circumstances can a chemist condemn a water for household use?

It is well known that the presence of chlorides, nitrites, etc., in water, is indicative of contamination with sewage, or with organic matter of some kind, and, by general consent, such waters are regarded as unsafe for household use. On the other hand, it must be admitted that the constant use of such waters for drinking is only occasionally followed by diseases which can be attributed to them. Certainly chlorides and nitrites are incapable of producing contagious diseases. Therefore, there must be another element in those waters which produce typhoid fever for example, that may or may not accompany the compounds mentioned. At present it is almost universally conceded that this element is a living microscopic germ, which develops and multiplies in the water. If this is true, it is obvious that the results of a chemical analysis are quite incompetent to prove the healthfulness of a water.

Granting this, it may be argued that chemical examinations are quite useless for sanitary purposes. The fact is quite otherwise. For although the chemist cannot detect the germs of disease, which likewise baffle the scrutiny of the microscopist, his analysis indicates the sources of contamination. It enables us, therefore, to trace the contamination to its source and thus determine its nature.

Perhaps it will be a somewhat startling assertion to say that the drainage from vaults containing human dejecta is not necessarily unhealthful. Yet the truth of it is demonstrated by the immunity from contagious diseases of thousands of families whose wells are situated close by and below such vaults. Sanitarians become greatly

excited over the condition of affairs in this respect all over the country, and they predict most direful epidemics. But, somehow, the epidemics do not come. Chemists examine the water, Boards of Health order the wells closed, and families complain of the injustice of it because they have never suffered from the use of the water. Evidently, theory and experience do not correspond.

Nevertheless, the explanation is simple enough. Let there be a single case of typhoid fever in a house when the well is thus contaminated, and the probability is that those who drink the water will also take the disease. The germs will be carried into the well. They may be disseminated from it through the entire community, and the result would be and often has been a wide-spread epidemic. This is a fact of observation and quite independent of any theory of the origin of disease. Therefore, chemical examinations of water are of value, not in that they prove that the water is unhealthful, but because they indicate the possibility of its becoming a vehicle of disease and point out the source of the contamination.

In regard to the examination of air there is much confusion as to the value of the results. I refer now to air as a vehicle of contagion, and not to its purity from a chemical point of view; and I trust no one will misunderstand my position in this regard, for there is no doubt as to the bad influence upon health of an excess of carbon dioxide, carbonous oxide, and other chemical impurities.

I maintain, however, that air which is chemically pure may be a vehicle of contagion; and that air, which is chemically very impure, may be perfectly harmless as regards contagion. In other words, sewer gas, whatever that strange combination of odors may be, is not, *per se*, a vehicle of contagion. If it were the population of New York City would be decimated every year. One of the most striking examples of a want of information concerning this subject was given last year by some of the physicians of the highest standing in New York, where the popular excitement about the danger of dirty streets was at its height. The doctors had a great meeting and foretold that there would be a great pestilence if the streets were not cleaned, and they worked themselves up into a state of excitement which frightened the people very much, and, perhaps, at the time they believed all they said. But the city escaped and the streets were not immaculate, and have not been so since.

I would not say that the health of the city was not affected by the

condition of the streets. Very likely it was; but the effect was merely that of air contaminated by the gases arising from the decomposition of refuse matter and utterly incapable of breeding a pestilence. Ammonia and sulphuretted hydrogen, and the various other gases which arise in this way do not produce contagious diseases.

But if the atmosphere carries the germs of disease it is not unlikely that these will be most active where the air is impure. For, if these be germs of living organisms they will doubtless find a suitable nidus for growth and multiplication where decomposition is going on, and they will be disseminated by the rising gases. It is very likely that some of them increase in virulence where they grow shielded from the free access of air. But so long as the germs are absent sewer gas or effluvia of any kind will not generate contagia.

About three years ago Professor R. O. Doremus read an article before the Medico-Legal Society of New York, entitled "Epidemics from a Chemical Standpoint." In the experiment which he then performed the permeability of sandstone, brick, etc., to gases was demonstrated. This fact is well known to chemists, but the experiment proves nothing more than that the poison of contagia may be retainad by the porous walls of houses. It should not be inferred, however, that the contagia are able to pass through the stone, for that has not been proved and is, indeed, highly improbable.

Experiment indicates that all the floating germs of contagious disease may be filtered from the air by means of cotton. Gun-cotton can be employed for this purpose, after which it can be dissolved and the germs will settle to the bottom of the solution where the microscopist can find them. There are also other methods of collecting them for examination. The microscopic examination of air is, therefore, very important. But it should only be entrusted to careful investigators—persons who are not too hasty in drawing inferences from experimental results. The more one studies the microbes of the air the more fully he realizes the immense field to be gone over before the results can be properly interpreted. To definitely declare the relation between these microbes and specific diseases now indicates a very superficial knowledge of the subject. For it is impossible to distinguish by sight between a bacterium that is virulent and one that is harmless.

The results of experience may therefore be summed up in a few words, thus: We have no means of determining when a water which

analysis shows is liable to become a carrier of disease does become active in its dissemination, nor can we yet determine whether the air we breathe is or is not loaded with the germs of disease.

But we cannot doubt that after years of continuous observation by competent persons satisfactory results willl be obtained. I regard it as a national misfortune that the National Board of Health has been unable to secure an appropriation adequate to continue its work and the publication of the *Bulletin*.

Skeptics may question the value of these investigations, but let us look for a moment at the actual results in saving human life, shown by the statistics of England and Wales for successive periods of ten years since 1841. The annual death-rate for those countries, for ten years, from 1841, was 22·4 in 1000 persons; for the next ten years it was 22·2, and for the next ten years, up to 1870, is was 22·5. For thirty years, therefore, it remained quite stationary. Then sanitary science was applied to diminish the death-rate, and in the next ten years, from 1871 to 1880, it fell to 21·5. This represents the saving of a quarter of a million lives. A further examination of the statistics also shows that this saving of life is in great part due to the effect of sanitary laws upon the prevalence of certain zymotic diseases. In exact figures, 0·78, or more than three-fourths of the improvement is due to this alone. The fever death-rate has fallen from 0·80 per 1000, in 1870 to 0·32 in 1880.

Another subject, upon which there is considerable misapprehension, is the efficiency of disinfectants. Here again the sanitarian can act without relying upon any theory of disease; for whether there be a living germ or a chemical poison the disinfectant must be strong enough to kill the one, or at least to render it inactive, and to decompose the other. The utter inefficiency of carbolic acid vapor, or of any ærial disinfectant whatever, in a sick-room, will be evident to any one who is familiar with the microscopic study of living germs. For it is known that they can withstand treatment with chemicals which would instantly destroy the life of higher organisms, and no atmosphere which we could breathe would destroy or materially affect the vitality or activity of disease-germs. It may be said that ordinary ærial disinfection is utterly useless. The only efficient method in the sick-room is the immediate disinfection of all refuse and thorough ventilation.

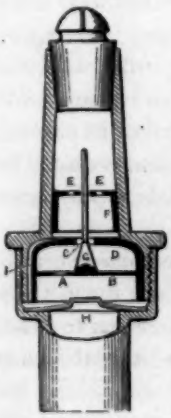
A more accurate knowledge, on the part of some persons, of the

capability of germs to resist destruction would prevent the advocacy of absurd and impracticable schemes for disinfection, such as the freezing out of yellow fever from a ship and others of like character. It may be assumed, with a fair degree of probability, that yellow fever, or any other contagious disease, will not be carried around in a ship's hold if the latter is thoroughly aired and ventilated, and by a proper regard to sanitary conditions the quarantining and disinfection of vessels, after long voyages from infected ports, would be rendered quite unnecessary.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE RAPPLEYE RHEOMETRIC GOVERNOR BURNER.

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, March 27, 1882.

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to which was referred for examination Rappleye's Rheometric Governor Burner, reports, that in accordance with the application, it has examined the merits of the Rappleye Governor Burner "as a device for controlling the flow and consumption of gas, and thereby maintaining a uniformity of light," and, as requested, add "an expression of opinion as to its desirability as a means of securing an economical consumption of gas."



A quantity of burners was furnished your committee for examination, from which casual selections were made, and tested with reference to the consumption of gas, and the light afforded at different pressures. A vertical section of the burner, with explanation of the cut, is appended.

A 5-foot burner, the gas being under 1 inch water pressure, consumed 4·9 feet gas per hour, and gave a light equal to 17·6 standard candles. The same burner, the gas being under a pressure of three inches, consumed 4·8 feet gas per hour, with a light equal to 16·75 candles.

A 3-foot burner, the gas under 1 inch pressure, consumed 2·95 feet gas per hour, the light being equal

to 11 candles. The same burner, under 3 inches pressure, consumed 3·2 feet gas, the light being equal to 12 candles.

Other experiments were made at the same and at a former meeting of the Committee with results not materially different. The consumption of gas by the same burner at different pressures, usually varying not more than one-tenth foot per hour, but in one instance, two and a half tenths.

The photogenic power of the city gas on the day of the above experiments, using the standard argand burner consuming 5 feet of gas per hour, was equal to 16·25 standard spermaceti candles, which is also about its average value.

Reducing the candle power in the above experiments to the rate of 5 feet consumption per hour, and comparing the same with that of the standard argand burner, we have the following results:

	Pressure.	Candle power with 5ft. gas.	Excess above Argand burner.
5 ft. burner,	1 inch.	17·95 candles.	10·40 per cent.
3 ft. burner,	3 inches.	17·45 "	7·38 "
3 ft. burner,	1 inch.	18·64 "	14·70 "
3 ft. burner,	3 inches.	18·75 "	15·38 "

The light furnished by these burners is thus seen to average 11·96 per cent. in excess of that of the standard argand burner. The flame is clear and steady, with no indication of smoke at any point above the initial pressure.

The common objection to the so-called governor burners, which merely present an unvarying check to the flow of gas, is that they require a maximum pressure to produce a fair light, while at lower pressures the light is much inferior to that of the open burner. The burner under examination meets a long felt want, in that it allows a maximum light at a slight increase of pressure above that required for an open burner, and maintains a uniform flow and light at any pressure in excess, that is liable to be encountered.

We think there is very little, if any danger of these burners becoming impaired by use from any effect the gas may have upon them, the working parts of the governor being allowed ample room to guard against friction. The Committee has had before it satisfactory evidence, that these burners, having been in constant use for the last fifteen months, were found on examination, to be in as good condition

as when new. There need be no apprehension of condensation occurring in these burners, from the fact that the burners while in use, being of a higher temperature than the gas, preclude the possibility of such condensation. If the case should occur that the burner occupies a point lower than the supply pipe leading to it condensation in the pipe might drip down into the burner. The light powdery deposit sometimes found would not interfere with the action of this governor.

In consideration, then, of the uniformity of gas consumption maintained by this burner under varying pressure, and its high photogenic qualities, we recommend it with confidence as affording a better light, at less expense, than any other practical appliance with which we are acquainted.

The above report was adopted at the stated meeting of the Committee on Science and the Arts, held May 3, 1882.

WILLIAM H. WAHL, *Secretary.*

THE SILVER AND GAY DYNAMOMETER.

By LUTHER H. SARGENT.

The dynamometer herewith illustrated is made by Messrs. Silver & Gay, North Chelmsford, Mass., and is designed to meet the requirements of mechanical engineers and others who have occasion to determine the actual amount of power required to operate machinery. It is upon the principle of one invented by the late Samuel Batchelder, called by him the Balance Dynamometer, which was described and illustrated in the JOURNAL of the FRANKLIN INSTITUTE, vol. 36, page 275, *et seq.* (October, 1843). It is made from new patterns, designed to combine such improvements and additions as will secure accuracy, convenience, and durability.

Referring to Fig. 1, the counter shaft, to bring the driven and driving pulleys into the same vertical plane, and the dash pot, to steady the scale-beam, both first applied by Mr. J. B. Francis, add much to convenience in placing and operating. The arrangement of the dash-pot stand and scale-beam, so that they may be used on either side, is for convenience in placing and to avoid crossing belts. The trucks, upon which the machine may be supported, make it easy to move and

to adjust in position. The speed indicator (Fig. 2) may be thrown into, or out of gear, at pleasure, and will indicate the number of revolutions in the interval. The scale-beam and plate-weight, on the size

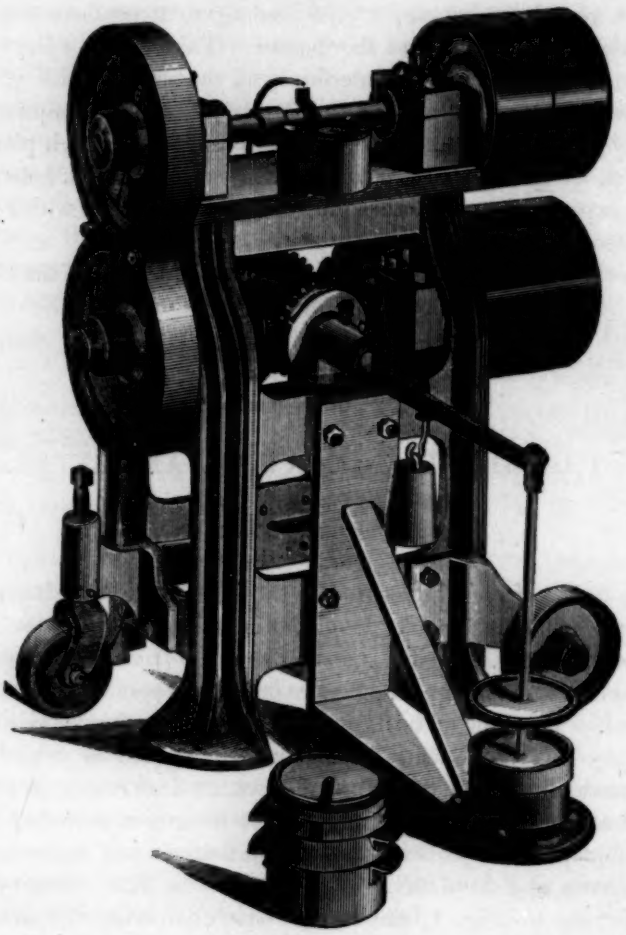


Fig. 1.

illustrated, are figured to indicate the force exerted at a point which, if revolving around the axis of the shaft, would describe a circle three feet in circumference.

The position of the hook-weight on the beam (balanced when at the

zero notch) will indicate by tenths of a pound, up to twelve pounds, the weight raised three feet to a revolution, and the plate-weights, when placed in the pan, will indicate, as figured, 5, 10, 25, 50, and 100 pounds, raised three feet to a revolution.

With the speed at 1000 revolutions per minute, and resistance requiring all the weights (202 lbs.) to keep the beam in a horizontal position, the result would be

$$\frac{202 \times 1000 \times 3}{33{,}000} = 18\tfrac{4}{11} \text{ HP.}$$

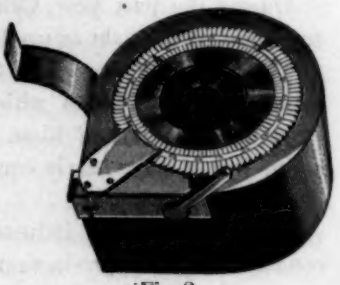


Fig. 2.

When W represents weight, and R revolutions per minute.

$W \times R \times 3$ = foot pounds, and

$$\frac{W \times R}{11{,}000} = \text{horse-power.}$$

The pulleys are three feet in circumference, so that the weights indicate also the force at their surface, or the strain on the belt. The size illustrated is capable of transmitting and weighing the power requisite to operate any machinery which can be driven by a belt four inches wide, running three thousand feet per minute.

THE AMERICAN IRON TRADE IN 1881.

The annual report of Mr. Swank, the Secretary of the American Iron and Steel Association, for the year 1881, has just been issued, and as usual is a document of more than ordinary value to those who are interested in the leading industry of our country. We present below a brief summary of the leading statements and facts which it contains.

The Secretary makes the remark at the outset of his report that the prosperity which was restored to the American iron trade in 1879, and which was continued in 1880, attained its highest development in 1881, which year he records as being the most prosperous one that American iron and steel manufacturers have ever known, as regards production, with the exception of the single item of iron rails; the output of 1881 was greater for every article enumerated in the

appended table, than in 1880, or in any previous year of our history. Another forcible feature is the fact that our importation of iron and manufactured products during the year 1881 fell off very considerably from the proportions they had assumed in 1880, when they reached the highest figures known in the history of the iron trade.

During the past year California, Colorado, and Washington Territory entered the field as producers of iron.

The total number of iron furnaces in the United States in 1881 is estimated to be 716, of which, at the close of the year, 455 were in blast and 261 out of blast. As regards the kind of fuel used, the active furnaces are nearly equally divided between bituminous, anthracite and charcoal.

The Bessemer steel industry is reported to be in a very flourishing condition. The production of Bessemer steel ingots, in 1881, amounted to 1,539,157 net tons, an increase of 335,984 tons over that of 1880, or 28 per cent. The strong and gratifying growth of this branch of the trade is clearly shown in the following tabulation.

Years.	Net tons.	Years.	Net tons.
1872	120,108	1877	560,587
1873	170,652	1878	732,226
1874	191,193	1879	928,972
1875	375,517	1880	1,203,173
1876	525,996	1881	1,539,157

Bessemer steel ingots were produced by thirteen works in 1881, of which seven are in Pennsylvania. Two new works, both in Pennsylvania, produced Bessemer steel for the first time in 1881. These were the Pittsburgh Bessemer Steel Company, limited, located at Homestead, near Pittsburgh, having two converters; and the Pittsburgh Steel Casting Company, of Pittsburgh, with one converter. Since the close of the year one new works has been completed and put into operation, namely, that of the Colorado Coal and Iron Company, located at South Pueblo, Colorado, which made their first blow on April 11, 1882. Besides these, two more Bessemer works, one at Scranton, Pennsylvania, and another at Chicago, are expected to go into operation before the close of the present year. The thirteen complete Bessemer works in the United States have thirty-three converters. The production of Bessemer steel rails in the United States,

during the two years (1880 and 1881), exceeded that of Great Britain.

The production of crucible steel ingots in the United States, in 1881, was 89,762 net tons and of open-hearth steel ingots, for the same year, 146,946 net tons. The production of all kinds of steel, in 1881, reached the unprecedented figure of 1,778,912 net tons. When it is recalled to mind that our collective production of steel in 1872 was only 160,108 net tons, the enormous figures of 1,778,912 for 1881 reveal the unexampled growth of this branch of the trade. Mr. Swank, in commenting upon these facts adds, that "they undoubtedly record the greatest metallurgical achievement ever accomplished by any country."

The number of miles of new railway constructed during 1881, reached the unprecedented figures of 9650 miles. It exceeded any record we have ever before made in any one year. The year 1871 contributed the next best record, 7379 miles, and the year 1880 the next, 7174 miles.

Without entering into the details respecting other items of the iron trade, which would unduly extend our review of Mr. Swank's valuable report, we will add, in conclusion, the following summary, which will be found useful for future reference, viz.:

Grand Summary of U. S. Statistics for 1881.

Production of pig iron in 1881, net tons,	4,641,564
Production of spiegeleisen in 1881 (included in pig iron), net tons,	21,086
Production of all rolled iron, including nails and excluding rails, in 1881, net tons,	2,155,346
Production of cut nails and spikes in 1881, included in all rolled iron, kegs of 100 pounds,	5,794,206
Production of Bessemer steel rails in 1881, net tons,	1,330,382
Production of open-hearth steel rails in 1881, net tons,	25,217
Production of iron and all other rails in 1881, net tons,	488,581
Total production of rails in 1881, net tons,	1,844,100
Production of crucible steel ingots in 1881, net tons,	89,762
Production of open-hearth steel ingots in 1881, net tons,	146,946
Production of Bessemer steel ingots in 1881, net tons,	1,539,157

Production of all kinds of steel in 1881, net tons,	1,728,912
Production of blooms from ore and pig iron in 1881, net tons,	84,606
Imports of iron and steel in 1881,	$61,555,078
Exports of iron and steel in 1881,	$15,782,282
Imports of iron ore in 1881, gross tons,	782,887
Production of Lake Superior iron ore in 1881, gross tons,	2,336,335
Production of iron ore in New Jersey in 1881, gross tons,	737,052
Total production of iron ore in the census year 1880, net tons,	7,974,705
Production of anthracite coal in the census year 1880, net tons,	28,646,795
Production of bituminous coal in the census year 1880, net tons,	42,420,581
Production of anthracite coal in 1881, gross tons,	28,500,016
Miles of railway completed in 1881,	9,650
Miles of railway in the United States, December 31, 1881	103,321
Iron ships built in the United States in the fiscal year ended June 30, 1881,	42
Net imports of foreign merchandise into the United States in the ten months ended April 30, 1882,	$579,462,510
Exports of domestic merchandise, out of the United States, in the ten months ended April 30, 1882	635,867,349
Net imports of specie into the United States, in the ten months ended April 30, 1882,	35,895,247
Net exports of specie out of the United States, for the ten months ended April 30, 1882,	22,708,081
Immigrants into the United States, in the calendar year 1881,	720,045

W.

The Tunnel Under the English Channel.—One of the experimental galleries of the submarine tunnel between France and England is nearly completed. The whole length of the tunnel will probably be about thirty-two kilometres (19·884 miles). It is thought that about one-tenth of this length will be ready for examination within a few weeks.—*Les Mondes.* C.

Photographs of Flying Birds.—M. Marey has succeeded by instantaneous photography and with the help of a photographic revolver similar to the one which was contrived by Jansen for observing the transit of Venus, in obtaining a complete analysis of different forms of locomotion, including the flight of birds. More than two years ago Muybridge obtained fine pictures of running horses, which were photographed in $\frac{1}{500}$ of a second. He also photographed flying pigeons but could only get a single picture. Marey has been able to obtain a dozen successive pictures in a second, each exposure requiring only $\frac{1}{1000}$ of a second. By arranging the pictures in a phenakistiscope the appearance of the flying bird may be reproduced under conditions which permit the analysis of different phases of the wings.—*Chron. Industr.* C.

New Process in Sulphur Mining.—Messrs. de la Tour du Breuil, having been engaged for ten years in the direction of sulphur mines in Sicily were struck by the great loss involved in the ordinary process of separating the sulphur from its gangue. The idea occurred to them to increase the heat of the boiling water by the presence of a salt which it holds in solution. They fixed upon chloride of calcium on account of cheapness and the uniformity with which it maintains a temperature of 120° (248° F.). The bath contains 65 per cent. of chloride of calcium and can serve indefinitely. The apparatus consists of two rectangular vats which are coupled and inclined at an inclination of ten per cent. As soon as the operation is terminated in one of the vats the boiling liquid is drawn into the other which has been previously filled with the ore. While the solution is going on there, which requires about two hours, the first vat is emptied and recharged; hence there is no interruption in the work and the bath is never cooled. A single fire is sufficient for the two vats, the heat being turned alternately from one to the other. This process presents the following advantages: 1. A cheap extraction of the sulphur, the cost being only about $1 per ton; 2. Great purity, analysis showing only $\frac{1}{20}$ of 1 per cent. of earthy residue and no trace of sulphurous or sulphuric acid; 3. Possibility of operating during the whole year since there is no production of sulphurous acid, which is so injurious to the public health and to agriculture.—*Comptes Rendus.* C.

Resources of Algiers.—Algiers abounds in deposits of copper, silver bearing lead, zinc, and especially iron. The Mokta mine yields 1800 tons of iron ore per day. Materials for construction, building stones, lime, plaster, marble, etc., are abundant. Salt is found almost everywhere. Mineral springs are very numerous. The number of workmen employed in the mines already exceeds 3500. The principal agricultural products are cereals and dry legumes. The cultivation of tobacco has increased largely since 1867. The greatest future expectations are based upon the culture of vineyards; the extent of land devoted to vines already exceeds 20,000 hectares (49,423 acres). The public works have already reached considerable importance. There are 10,506 kilometres (6528 miles) of highway, and 1282 kilometres (796·6 miles) of railroads under construction.—*Chron. Industr.* C.

Tempering by Compression.—L. Clemandot has devised a new method of treating metals, especially steel, which consists in heating to a cherry red, compressing strongly and keeping up the pressure until the metal is completely cooled. The results are so much like those of tempering that he calls his process tempering by compression. The compressed metal becomes exceedingly hard, acquiring a molecular contraction and a fineness of grain such that polishing gives it the appearance of polished nickel. Compressed steel, like tempered steel, acquires the coercitive force which enables it to absorb magnetism. This property should be studied in connection with its durability; experiments have already shown that there is no loss of magnetism at the expiration of three months. This compression has no analogue but tempering. Hammering and hardening modify the molecular state of metals, especially when they are practiced upon metal that is nearly cold, but the effect of hydraulic pressure is much greater. The phenomena which are produced in both methods of tempering may be interpreted in different ways but it seems likely that there is a molecular approximation, an amorphism from which results the homogeneity that is due to the absence of crystalization. The advantages of the new method are obvious. Being an operation which can be measured, it may be graduated and kept within limits which are prescribed in advance; directions may be given to temper at a specified pressure, as readily as to work under a given pressure of steam.—*Chron. Industr.* C.

Thermal Laws of the Exciting Spark.—Villari calls the exciting spark of the discharge of a condenser the one which is produced against the exciter; the one which is formed in a break of circuit he calls the conjunctive spark. He deduces from his experiments the following laws: 1. The heat of the exciting spark increases more rapidly than the third power of the charges for a small potential. 2. It increases as the squares of the charges for a mean potential. 3 It increases nearly in the ratio of the charges for a very high potential. When the potential remains constant the heat of a single exciting spark increases a little less rapidly than the charge. In varying the potential of a constant charge which he had accumulated in a variable number of jars he found that the heat of a single exciting spark increases more rapidly than the potentials when they are small, like the potentials when they are mean, much less than the potentials or even decreasing when the potentials increase if they are very high.—*Comptes Rendus.* C.

Spontaneous Galvanization.—M. P. Paul, Civil Engineer, records a curious accident which happened in the workshop of M. Fleury. The feed-water produced thick incrustations and the proprietor was advised to put fragments of zinc into the boiler. After a few days, in spite of the greasing, the machinery began to act sluggishly. The piston began to grip, and in a few days more it was almost impossible to make it move. The pump was then dismounted and the piston was found covered with a thick layer of adherent copper. It was put upon the turning lathe and in some places, which had been made elliptical by wear, the layer was so thick that the turning was made in pure copper. The following explanation is given. The boiler was connected with the engine by copper tubes. The particles of zinc which were carried in the steam formed with the tubes an immense number of small galvanic couples. The piston principally attracted the copper, both on account of its own continual movement exercising an attraction of mass upon the molecules, and on account of the heat which facilitated their permanent deposit. The result seems to show that the temperature of 144° to 150° (291·2° to 302°F.) was particularly favorable to the production of the phenomena. It is probable that the electric properties of the steam also aided in its development.—*Genie Civil.* C.

Electrified Lily.—During a storm at Montmaurin, in the upper Garonne, M. F. Laroque witnessed a curious electric phenomenon. Looking towards a clump of lilies, he saw the highest plunged in a diffused violet light which formed an aureole around the corolla. This light lasted for 8 or 10 seconds. After it had ceased he approached the lily, which he found, to his great surprise, wholly deprived of its pollen, while the neighboring flowers were covered with it.—*La Nature.*

Evaporation in Circular or Elliptic Basins.—If a liquid body sends vapor into an unlimited atmosphere there will proceed from each element of its surface, during a unit of time, a quantity of vapor proportional to an electric charge which is present and in equilibrium upon the element. The lines of the vapor currents correspond to the lines of electric force, and the surfaces of equal vapor pressure to the surfaces of equal potential. The electric equilibrium of an infinitely small circular or elliptic plate is the electrostatic analogue of the problem of the evaporation of a liquid contained in a basin of circular or elliptic contour.—*Les Mondes.* C.

Mummied Plants.—Dr. Schweinfurth has examined the garlands which covered the breast of the mummy of King Ahmos 1st, which was one of the most important treasures in the great discovery at Deir el Bahari. The garlands are composed of leaves of the Egyptian willow, *Salix safsaf*, folded twice and sewed side by side along a date branch, so as to form clasps which enclose isolated flowers of *Acacia klotica*, *Nymphæa cærulea*, *Alcea ficifolia*, and a *delphinium*, which he thinks to be Oriental. The garlands of other kings contain flowers of *Carthamus tinctorius*, and the leaves which are woven in clasps are those of the *Mimusops kummel*. Leaves have also been found in the coffin of Neb Seni, a high priest of the twentieth dynasty, of the *Cucumis citrullus* These leaves and flowers date from some centuries before the epoch of the Trojan war; Dr. Schweinfurth has preserved a great number of them, by moistening them, then putting them in alcohol and afterwards expanding them and drying them, so as to form a small herbarium of plants that are thirty-five centuries old. The color of the chlorophyll is remarkably preserved, being violet in the delphinium and green in the cucumis.—*Les Mondes.* C.

Action of Stannic Salts upon Animal Matter.—When silk is steeped in a solution of stannic chloride and then thoroughly washed in order to remove the excess of uncombined salt it is found to have increased in weight and to have absorbed a quantity of stannic oxide proportioned to the concentration of the solution and the length of immersion. If the silk is then passed into boiling suds, washed and replunged in the bath it fixes a new quantity of tin and by repeating these operations its primitive weight may be doubled. This furnishes a ready method of loading silk with a colorless oxide, in order to receive a permanent dye of any hue that may be desired. The weight of silk which has been thus loaded with stannic oxide may be increased still more by putting it in a solution of any tannic material. This cannot be done, however, where delicate shades are required, because the impurities of the tannin produce a muddy tint. Skins which are treated with solutions of bichloride may be tanned in a very short time.—*Bull. de la Soc. Indust.* C.

Grafting Bones.—The experiments of Ollier, in transplanting bones upon rabbits have been received with considerable doubt by Wolf and others. W. MacEwen reports the case of a patient who had necrosis of the humerus which had destroyed considerable portions of the periosteum. He had occasion to operate upon several subjects with anterior curvatures of the tibia from whom he removed wedge-shaped portions of bone in order to straighten the bent limbs. These portions, with their periostium, were divided into numerous small fragments which were immediately placed in a channel prepared to receive them in the diseased arm. These small portions gradually united, adhering to the summit of the humerus on one side and to the condyles on the other, and finally forming a solid shaft about half an inch shorter than the humerus of the opposite arm. In this way a useless arm was rendered perfectly serviceable. The transplanted portions were taken from six different limbs, with their periosteum and their marrow, and placed in the arm of a young lad, in an intermuscular space which was freshly opened by the scalpel in order to receive them. The grafts not only remained entirely in the tissues, but they formed a perfect union with one another, making in all four and a half inches of bony transplanting in which formed a new humerus that can be used as well as that of the other arm.—*Comptes Rendus.* C.

Lincrusta.—Frederick Walton, the inventor of Linoleum, has introduced a new article, under the above name, for the purposes of plastic decoration. It consists of a compressed mass of cellulose, paper, cork, etc., thoroughly impregnated with oxidized linseed oil and resin. The mass is at first doughy, so that it can be spread or pressed in thin or thick sheets or moulds. It becomes gradually leathery, pliable, elastic, tough, not affected by water or by the influences of the weather, and is a bad conductor of heat. It is much cheaper than pressed leather or its papier maché imitations, and can receive much deeper, sharper and more lasting impressions. Lincrusta tapestries, with decorations in imitation of ivory, gold, silver, bronze, etc., can be furnished at about one-fifteenth the price of leather.—*Der Techniker.*

Electric Currents Produced by Distant Lightning.—In 1826 M. D. Colladon published an account of disturbances of his galvanometer by a storm, which was so far from Paris that no clouds were visible within 30 degrees from the zenith. Peclet, in his *Traité de Physique*, gives a note upon Colladon's observations in which he says: "During a storm the needle of the galvanometer is in continual motion; each flash is immediately followed, sometimes even preceded, by a sudden change in the direction of the deviation, or by a violent increase. In some cases the deviation passes instantly from the positive to the negative maximum, or inversely; these effects continue even when the flashes are two or three leagues off, provided the air is very damp and the sky covered with clouds." In 1879 M. Renè Thury, son of a professor in the University of Geneva, stretched a copper wire horizontally between two houses, at the height of the roofs and communicating with the earth by means of water pipes. Two telephones were connected with the wire, one of which had a resistence of 4·5 ohms, the other of 2·5 ohms. In every thunder storm the flashes of lightning have always been accompanied by a very characteristic crackling in the telephones. This noise is heard at the same instant that the flash is seen, whatever may be its distance, and results, consequently, from the induction of the distant discharge upon the wire. Every flash which is visible to the eye is heard in the telephone, even when it is so distant that there is no audible thunder.—*Comptes Rendus.* C.

Melting Steel by Electricity.—Dumas recently exhibited to the French Academy an ingot of steel, which Siemens had melted by an electric current in a crucible of magnesia at the Palais de l'Industrie, in the British section of the Exposition. The fusion was completed in 14 minutes, requiring for the supply of the electrodynamic machine a less expenditure of coal than would have been needed for the direct melting in an ordinary furnace.—*Comptes Rendus.* C.

New Determination of Jules' Equivalent.—Cantoni and Grosa have determined the mechanical equivalent of heat by a series of experiments in which they substituted mercury for water. Its great thermal conductibility and the relative invariability of its specific heat at the low temperatures which they employed induced them to make the substitution. The method of experimenting consisted in the sudden arrest of a mass of mercury, falling from a given height and consequently provided with a known amount of dynamic energy. The increase of temperature at each experiment was carefully measured and the dynamic equivalent of a calone deduced by a simple calculation. The mean of all the results is almost precisely the same as that which Joule obtained from his most satisfactory experiments. The agreement of the values which are furnished by two processes that are so distinct seems to give complete assurance of the accuracy of the results.—*Acad. dei Lincei.* C.

Book Notices.

Bi-Centennial Souvenir: Philadelphia, What it is. Philadelphia Insurance Guide. J. H. C. Whiting. Review Publishing and Printing Co., Philadelphia, 1882. Price, 50 cents.

This is a pamphlet, in two parts, of 72 pages, giving first a brief view of the early history of the city, then a more extended but succinct description of its present immense industrial development. The second part is a convenient and portable guide or directory to all the insurance companies, agents and brokers thereof, in the city, together with a history of the commencement and struggles of insurance in the provinces and afterwards in the United States. As shown therein, it was in Philadelphia that marine and fire insurance were first practiced and developed on this continent. It can safely be stated that the

above named is the most concise and forcible presentation of the advantages for residence and the manufacturing greatness of Philadelphia that has yet been published. The chief features and arrangements of the city and environs, prominent buildings, railroads, bridges steamships, institutions, and chief industries mentioned by names, are given in a form easily grasped and retained by the memory. The first part concludes with a grouping of terse facts and data astounding in their magnitude. One seems to be reading of a second London; and truly the resemblance is great—if not fully as to population, certainly in extent, location, arrangements, and grandeur of edifices; also as the place of commencement in the Union of all the chief elements of national strength and metropolitan greatness. The directory for insurance companies, agents and brokers could not well be improved, and must be seen to be appreciated.

We have been especially interested in the plain showing made in this work—accompanied by data, tables, etc.—that the industries of Philadelphia have been much underrated in the census of 1880. In some preliminary data published from that document—though thereby it is conceded that the amount of capital invested in manufactures in Philadelphia exceeds that of any American city—yet in value of productions she is rated as second, whilst at the same time it is announced, just preceding the table, that the capital and annual value of productions of such great interests as brewers, distillers, and others, whose productions would count many millions of dollars annually, are not yet ready, and not included in the tabulation. Doubtless the latter is believed to be final by most persons, for the explanatory note is not at all prominent.

[In this connection we think we are not indiscreet in stating that Mr. Lorin Blodget—working in co-operation with the city authorities and the leading manufacturers and scientific and mechanical institutions—is collecting unimpeachable statistics by which he will prove, in lectures before the Franklin Institute in November, that the annual value of Philadelphia industries is nearly double the amount accorded to them in the census of 1880.]

It is also an interesting fact, shown in this volume, that although Philadelphians must lament the departure of much of the former European, Indian, and China trade, which made their city the commercial emporium of the United States until about 1830, the tonnage

of its numerous coastwise and collier vessels alone exceeds by more than 300,000 tons that of all American vessels in the United States engaged in the foreign trade. While, from this volume, many citizens will learn and remember more than ever before of the extent, wealth, and vast industries of the place of their birth or adopted residence, the Franklin Institute can feel a vivid pleasure in the recital of the present greatness of a city which Franklin loved to call "Dear Philadelphia"—a city which, though in his day small in population, performed deeds of wonder in moulding the destinies of the nation and in promoting science and the mechanic arts. N.

THE WEST, FROM THE CENSUS OF 1880. By Robert P. Porter.

A robust and handsome volume, published by Rand, McNally & Co., of Chicago, with the above title appears to be an appropriate contribution to the present demand for recent and authentic information as to the resources and development of the Western States and Territories. Mr. Porter is a prolific writer, and having the census returns for 1880 at his command, in advance of their official publication, he has used them with effect in completing statistical comparisons for the Western States on almost every possible subject—population, agriculture, manufactures, social and sanitary statistics, debt, taxation, revenue, etc. The value of such a compilation is great if faithfully made, as this appears to be, and perhaps for the first time it is made complete for a group of States in their natural association. Mr. Porter acknowledges valuable aid from Henry Gannett, Prof. W. P. Jones, Dr. Henry Randall, and Prof .James H. Blodget, and it is evident that the body of the volume covering the history and specific description of soils, climate, social condition, and progressive development of these States has been very carefully written. The various parts of the work should have been separately credited to identify the share of each author and to give proper credit for the historical, descriptive, and scientific portions.

The defects of the present census on many of the business and crop statistics detract much from the value of the work. The live stock, sheep, cattle, etc., are not much more than half covered, the deficiency being greatest in Kansas, Nebraska, Montana, and the territories generally, precisely where information is most desired. The entire class of returns taken by personal canvassers, except mere population, is

more defective in the census of 1880 than at any former period, the errors arising from haste, misdirection, and lack of competence of the persons employed. The errors are all on the side of deficiency, or omission, and range from thirty to fifty per cent. in most cases, especially for agricultural and industrial products. There is no danger that the public will get an exaggerated estimate of the productive capacity of Kansas, Nebraska, or Colorado from the figures here given as the most recent on these subjects. These figures, as for corn, wheat, cattle, sheep and wool, hogs and hog products, etc., are each fully twice as great for 1882 as are here for 1880. Mr. Porter should have given some indications of these recent facts, especially for the benefit of those who, in Europe, are likely to take the census of 1880 as authority until the current decade ends with 1890. In the ordinary measure of time 1882 is already more than half a decade in advance of 1879–80—really 1879 for these Western States. But on the whole, the value of this as a work of reference for the Western States is great, and it is one that has been needed for some time.

Some errors are noticeable even in the hasty review now made, as, at page 199, where the mean temperature of Lansing is given at 49·1° and that of Detroit 45·5°; neither can be correct. Also, "the distribution of the rainfall throughout the seasons is, for the upper peninsula, 19 inches for the spring, 27 inches for the summer, 27·3 for the autumn, and 19·1 for the winter"—we quote exactly. This would be a total rainfull of 92·4 inches for the year, and if the quantities were not stated in words we should think it a misprint of figures only. The annual quantity is 30 inches. We also notice that the ink used in printing on the fine paper used for the book has not yet penetrated sufficiently to stay under the touch of the careless hand, a suggestion to readers as well as to the printers. L. B.

House Drainage and Sanitary Plumbing. By Wm. Paul Gerhard, Civil and Sanitary Engineer. Newport, R. I.

The figures and charts which give statistical information relative to the "ills that flesh is heir to" are uninteresting to the general public if they stand alone, unaccompanied by anything calculated to furnish a key to the intelligent and comprehensive understanding of the cold tabulated facts. This condition of things is most undesirable, inasmuch as it is of the utmost importance that the general public should

not only recognize the value of such statistics, but should be able to take a lively interest in them, and to appreciate their full significance.

Nothing could be better adapted to the attainment of this desideratum than the annual reports now published by the State Boards of Health that have been established in at least four of the United States —Massachusetts and Michigan took the lead in this matter, and New Jersey and Rhode Island have followed—and it is from the Fourth Annual Report (being that for the current year) of the last-mentioned State that the work under consideration is a reprint.

It is a lamentable fact that had such advice as is contained in this pamphlet been universally acted upon in the past, and continued to be acted upon now, much of the ill-health that exists among civilized peoples would not be; several common and serious diseases might have been almost if not entirely eradicated, and many premature deaths would not have occurred. The evidence is overwhelming; but as this is not the place for its consideration, it must suffice to say that where sickness is not directly traceable to sanitary defects, the sequence of cause and effect may be established indirectly, and sometimes perhaps only inferentially, through the medium of heredity or contagion.

It is gratifying to be able to state that there are signs that the time is rapidly approaching when there will be a competition among cities and towns in the reduction of their respective death-rates to a minimum, particularly with respect to those diseases which are most conclusively shown to be associated with bad drainage.

The writer of the work before us claims that it is "the outgrowth of much study and experience." It has the merit of being eminently practical and amply illustrated, and comprehends more valuable information upon the subject it treats of than we recollect to have seen in a work of the same size. W. B. C.

Franklin Institute.

HALL OF THE INSTITUTE, October 18, 1882.

The meeting was called to order at the usual hour, with the President, Wm. P. Tatham, in the chair.

There were present 115 members and 6 visitors.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the stated meeting, held Oct. 11th, 8 persons had been elected members.

The Secretary, from the Committee on Science and the Arts, reported, by instruction, that the Committee, after full investigation, had reported a recommendation for the award of the Scott Legacy Medal and Premium to the Pratt & Whitney Co., of Hartford, Conn., for their Standard Gauges, Taps and Dies, and to Henry R. Heyl and Hugo Brehmer, of Philadelphia, Pa., for their Wire Book-Sewing Machine. He reported also that the above recommendations had been duly advertised for three months, and that no objections had been offered to the recommendations.

It was decided, on motion of Mr. Hector Orr, that the recommendations of the Committee on Science and the Arts be approved, and that the Secretary be directed to notify the Committee on Minor Trusts of the Board of City Trusts, of the action of the Institute.

Mr. C. J. Hexamer, from the Special Committee on the Prevention of Fires in Theatres, reported progress, and the Committee was continued. Similar report was made and similar action taken, in regard to the Special Committee on Memorial to Mr. Briggs.

The Secretary's report included a description of the Edison Electric Lighting System in New York, and a detailed account of the Cable System of Street Railways. The latter subject was very fully discussed by Messrs. Heyl, Freeman and Shaw. The following mechanical inventions were also shown and described: Pohl's Differential Car Starter; Spratt's Improved Mercury Seal Trap; Addis' Fire-escape; Avery's Anti-friction Bearing, and De Beaumont's Condenser.

Mr. E. Mallett, Jr., of New York, next read a paper entitled "Experiential Principles of Controlled Combustion," describing certain peculiarities of furnace setting and operation.

The paper provoked an animated discussion, which was participated in by Messrs. Shaw, Strong, Grimshaw, Henderson, Ronaldson, and the author. The paper has been referred to the Committee on Publication.

The meeting was thereupon adjourned.

WILLIAM H. WAHL, *Secretary.*